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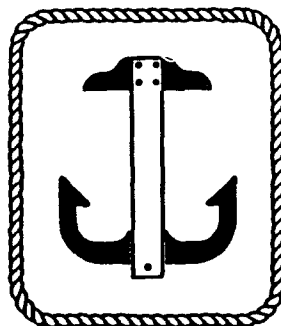
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FAST SEALIFT
CARGO HANDLING TECHNOLOGY CONCEPT
REPORT

6 December, 1991



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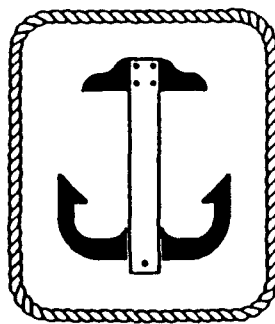
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FAST SEALIFT CARGO HANDLING TECHNOLOGY CONCEPT
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Drawings

JJH-2852-00-01	Arrangements RO-RO/Container Convertible Full Scantling Ship
JJH-2852-00-02	Arrangements RO/RO-Container Convertible Shelter Deck Ship
JJH-2852-00-03	Container Guide/Hatch Covers
JJH-2852-00-04	Container Guides - Portable

FAST SEALIFT CARGO HANDLING TECHNOLOGY CONCEPT

1. Introduction

The cargo handling system described herein enables a ship to carry containers, break bulk cargo, or roll-on/roll-off (RO/RO) vehicles throughout the cargo carrying spaces. This is done without conversion and only minor changeover required from one mode to the other. The system is developed to a concept level only, and further detailed engineering work is required for a complete design.

The subject cargo handling system is shown integrated into a ship design to illustrate the concept. Any basic cargo ship design could be used, however an existing baseline conceptual commercial/sealift design was chosen to allow comparison with cargo handling systems shown on that design. The baseline design used is the Maritime Administration (MarAd) PD-337, "Commercial Cargo Ship for Sealift in the Year 2000".

2. Background

2.1 General

Thirty-five years ago, all dry cargo other than bulk was carried in break bulk ships. Individual items were lifted into and out of the hold one piece at a time, or pallet loaded. This was a slow, man-power intensive way to handle cargo, and over the years new means have been developed to more efficiently load and offload cargo. Most commercial seaborne cargo today is carried in standard ISO containers, which are little more than metal boxes either 20 or 40 feet long, 8 feet wide, and of heights varying from 8 to 9-1/2 feet. The most widespread and cost effective means of carrying these boxes is in cellular containerships, such as shown in figure 1. These ships have specialized racks into which containers are lowered, usually by shore based gantry cranes. This allows for very rapid loading and unloading of ships, provided suitable port facilities are available. However, unless the ship has its own cranes, this advantage is largely nullified in undeveloped ports, such as often exist in third world countries. It also requires that cargo be able to fit into the footprint of a standard container.

Much military cargo can be containerized and carried to established ports in containers. Most military "surge" cargo, however, (cargo needed at the start of an armed conflict) cannot be easily carried in containerships. This surge cargo is mostly wheeled vehicles, many too large to fit in containers. Their most efficient method of transport is to drive them on and off a specialized RO/RO ship, such as shown in figure 2.

These different cargo handling systems require ship arrangements which are usually incompatible with each another. Containers are lifted on and lifted off vertically (LO/LO) through hatches in

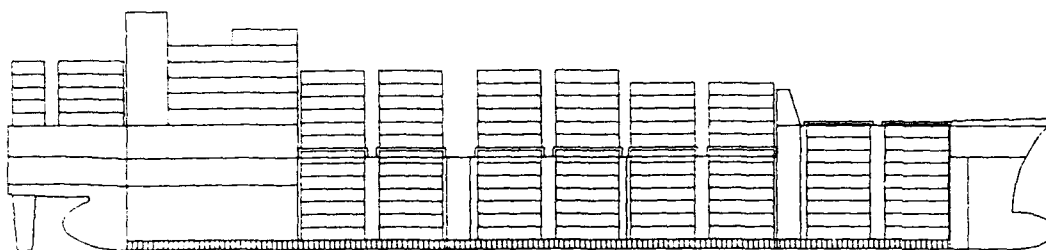


Figure 1: Typical Container Ship

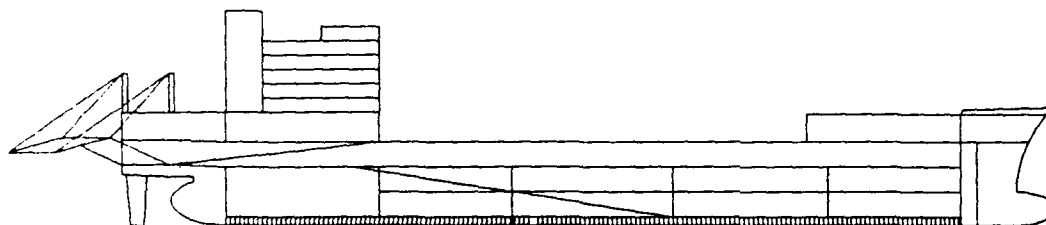


Figure 2: Typical RO-RO Ship

the main deck. There are no tween decks in a container ship, and the containers in the holds are stacked in vertical cells from the tank top to the underside of the weather deck hatches. RO/RO cargo, on the other hand, rolls aboard on its own wheels via ramps and then is dispersed to all the holds at each deck through a system of ramps and watertight doors. A RO/RO ship requires many smooth interior decks, because its cargo capacity is measured in vehicle parking area. The requirement for large, flat, open spaces precludes installation of fixed vertical container guides. While RO/RO ships sometimes carry containers on deck, they never carry containers inside the holds intended for RO/RO cargo.

U.S. shipping companies are very active in the container and break bulk trades. However, except for automobiles, there has not been sufficient U.S. RO/RO trade for U.S. shipping companies to operate large numbers of specialized ships. Since auto carriers are not suitable for military RO/RO because of their restricted deck heights, there is a shortage of suitable RO/RO ships available to the military in the U.S. Because of this shortage, foreign RO/RO ships were chartered for the Persian Gulf buildup, and others were recently purchased to build up the Ready Reserve Fleet (RRF). Many foreign ships, however, would probably fail to meet U.S. Coast Guard safety requirements for commercial operation, and maintaining a large fleet of cargo vessels in reserve would be very expensive.

The most cost effective method for the military to obtain additional RO/RO ships and maintain them in readiness would be to

have them used in commercial service until such time as they are needed for military use in a national emergency. This peacetime commercial operation would greatly offset the Government's costs. The ships would be earning income and maintained in continuous operating condition, fully crewed, instead of being idle at dockside. This will also stimulate the U.S. shipping industry with modern efficient ships and help to reduce the deficit in the U.S. balance of trade. However, since U.S. shipping companies deal mostly in containerized cargo, they would probably not agree to operate and maintain a sizable fleet of dedicated RO/RO ships.

The cargo handling system described herein, with fast convertibility of the cargo spaces from container to RO/RO and/or break bulk and back again, would allow commercial operators to use the sealift ships thus equipped in the presently active U.S. trades.

2.2 Baseline Ship Design

MarAd PD-337 has four holds arranged for containers, two twin cargo crane sets serving all the holds, and machinery and accommodations aft. There is no forecastle. The hull is a "full-scantling" design, with one compartment subdivision to the main (weather) deck. Detailed technical background design data and cargo market analyses are contained in the MarAd report. Principal characteristics are as follows:

Length overall	199.8 M	(655.5 ft.)
Length between perpendiculars	188.0 M	(616.8 ft.)
Beam, molded (PanaMax)	32.2 M	(105.6 ft.)
Depth, molded	18.0 M	(59.1 ft.)
Draft, maximum	11.0 M	(36.1 ft.)
Draft, design	9.2 M	(30.2 ft.)
Light ship weight	15,300 mt	(15,100 L.T.)
Displacement, maximum	5,900 mt	(45,200 L.T.)
Deadweight, maximum	30,600 mt	(30,100 L.T.)
Displacement, design	36,700 mt	(36,100 L.T.)
Deadweight, design	21,400 mt	(21,100 L.T.)
Fuel oil, bunker "c"	3,000 mt	(2,950 L.T.)
Diesel oil	200 mt	(197 L.T.)
Containers	2,036 TEU	
RO/RO Area	4,140 sq.M	(44,600 sq.ft.)
Type machinery	Slow speed diesel	
Shaft power, ABS MCR	21,600 kw = 29,350 BHP	
Propeller revolutions	89	
Sustained sea speed	20 knots	
Fuel consumption, at sea	73 mt/day (72 L.T./day)	
Fuel consumption, in port	15 mt/day (15 L.T./day)	
Range	14,100 naut. mi.	

Complement	
Deck	11
Engine	7
Stewards	2
Permanent crew	20
Riding crew, cadets, spares	11
Total accommodations	31

During a MarAd briefing on the background of their PD-337 design study, it was pointed out that self-sustaining cargo gear and relatively small ship size were positive attributes in many ports where the U.S. has an active trade. Pd-337 was developed for this trade. The subject ship and cargo handling system are also aimed at this type of commercial trade.

3. Description of Subject Cargo Handling System Concept

3.1 General

The subject cargo handling system is designed so a ship can handle one type of cargo throughout (either RO/RO, containers or break bulk), or all three types simultaneously in different holds and/or different decks. The convertibility concept is based on:

- (1) A standard RO/RO ship arrangement, with a hinged ramp to the pier and interior fixed ramps to all levels of the holds, watertight doors in bulkheads between holds, and closed hatches providing efficient horizontal loading and stowage of RO/RO cargo throughout;
- (2) Hatches over all holds, for vertical movement of LO/LO cargos, including containers in cell guides, with all interior tween deck hatches open and all watertight doors closed.

All hatches, including main deck hatches, are flush to facilitate movement of RO/RO at all levels. The hatches are sized for efficient container stowage when open. Steel angle container cell guides are fixed to the underside of all tween deck hatch covers. The guides are out of the way in the overhead when the hatches are closed for RO/RO or break bulk operations, and they are automatically deployed when the covers are opened for container loading.

Additional cell guides are required at the lowest levels, where there are no hatches, to complete the cellular arrangement. These guides are fixed to the structure in areas where they do not interfere with RO/RO or break bulk cargo. However, where they would impede RO/RO access (i.e. in way of watertight doors at ends of holds, etc.) or restrict RO/RO or break bulk stowage, they are removable. Installing or removing the portable cell guides in the lower holds and locking open or closing the tween

deck hatch covers constitute the only operations necessary for converting the cargo handling spaces.

The same equipment and hold arrangements used for other cargo may also be used for break bulk cargo. It can be loaded in any part of the hold area in the standard manner, using ship's gear or shoreside gear and by activating the hatch covers. The integral container guides on the tween deck covers should not interfere with operations. Care must be taken, however, in handling heavy items through open tween deck covers, to avoid damaging the guides. Portable guides in the lower holds would be removed at this time. Items too large to pass through the hatches must be stowed on the weather deck.

It should be noted that if different types of cargo are to be handled simultaneously, clear horizontal paths must be maintained for RO/RO and clear vertical paths for containers and break bulk.

The concept of attaching container guides to the underside of hatch covers was patented in the late 1960s. Four ships (MarAd Design No. C5-S-78a) were built at that time for the Moore-McCormack Lines, Inc. under the MarAd construction-differential subsidy (CDS) program with a limited application of the patented system. They had one convertible RO/RO tween deck and fixed container cells below. Figure 3 shows an arrangement of that design.

The system as built suffered from both technical and economic problems, although all four ships are still in service at this writing. Three of them, T-AVB Curtis, T-AVB Wright, and Cape Nome, are in the Ready Reserve Fleet (RRF). The fourth, Rover, is in commercial service. There were several reasons why Moore-McCormack did not continue to use the convertible feature of their hatch/container cell system:

- A. The trade changed from calling at a single port at each end of the route to a multi-port operation. This required frequent off-loading of RO/RO cargo over the holds to gain access to the containers. For more efficient container operations, it was decided to stow RO/RO clear of the holds.
- B. The ship was designed assuming 8-foot high containers in the holds. The trade then went to 8'-6" high containers, and an entire layer was lost by a small margin of clearance when the tween deck hatches were closed.
- C. There was frequent misalignment caused by too much play in the system and a latching/locking arrangement which was not sufficiently rigid. The misalignment caused some containers to hang up passing from one set of guides to the next. Some containers also had projections that increased the chances of hanging up. The fact that 4"x4" angles were used as container guides under the hatches,

rather than the 6"x6" angles used today, made the alignment problem even more critical.

Of the above factors, only the last one seriously affects the hatch cover/container cell design of this ship. The concept described in detail in Section 3.3.3 is designed to overcome that problem.

Two optional ship arrangements are used herein to demonstrate the subject cargo handling system, with minor changes from the MarAd PD-337 design. One arrangement is of a "full scantling ship", with watertight subdivision to the weather or main deck. The other is of a "shelter deck ship", with watertight subdivision up to the upper tween deck or second deck. A high forecastle has been included on both to accommodate the largest military helicopters, which will not fit below decks.

The arrangement of deck and bulkhead structure, hatches and container cells is asymmetric in both ship options, with the longitudinal center of the hatches and cells slightly to port of the ship's centerline. The fixed vehicle ramps in the holds are as far to starboard as possible. This will minimize the loss of container cells in way of the ramps. Two 40-foot cells only are lost to these ramps, for a total of 24 TEU. A full load of containers in the cells may require asymmetric water ballast on the starboard side to compensate for the uneven container load.

RO/RO and break bulk cargo will stow the full width of the decks and on the ramps, therefore they will be unaffected by the hold asymmetry. Experience in military RO/RO operations reveals that ships sometimes list to starboard during loading and unloading, due to the concentration of vehicles entering or exiting on that side. Asymmetric ballasting on the port side will alleviate this condition.

The inner bottom ballast tanks can provide all that is necessary to counteract the above-mentioned asymmetric loading conditions.

3.1.1 Full Scantling Ship

This ship has the same dimensions as the MarAd ship and virtually the same arrangement except for deck heights. There are two tween decks, providing headroom for commercial highway trailers at three levels below deck. This will also accommodate all military vehicles. All cargo spaces are arranged for complete convertibility. Principal characteristics of the full scantling ship are as follows:

Length overall	200.0 M	(656.2 ft.)
Length between perpendiculars	188.0 M	(616.8 ft.)
Beam, molded (PanaMax)	32.2 M	(105.6 ft.)
Depth, molded	18.0 M	(59.1 ft.)
Draft, maximum	11.0 M	(36.1 ft.)
Draft, design	9.2 M	(30.2 ft.)

Light ship weight	16,000 MT	(15,700 L.T.)
Displacement, maximum	45,900 MT	(45,200 L.T.)
Deadweight, maximum	29,900 MT	(29,500 L.T.)
Cargo Deadweight, maximum	26,500 MT	(26,100 L.T.)
Displacement, design	36,700 MT	(36,100 L.T.)
Deadweight, design	20,700 MT	(20,400 L.T.)
Cargo deadweight, design	17,300 MT	(17,000 L.T.)
Fuel oil, bunker "c"	3,000 MT	(2,950 L.T.)
Diesel oil	200 MT	(197 L.T.)
Fr. water, stores, crew & effects	200 MT	(197 L.T.)

Machinery and accommodations: Same as PD-337

Cargo Capacity: containership 1,973 TEU containers, and
1,360 sq.M (14,600 sq.ft.)
enclosed RO/RO area

Cargo Capacity: RO/RO 10,200 sq.M (110,000 sq.ft)
enclosed area, and 2,400 sq.M
(25,000 sq.ft) on weather deck

Cargo Capacity: Break Bulk 51,000 cu.M (1,800,000 cu.ft)
bale cubic

Pertinent differences from the baseline ship are as follows:

Item	Subject Ship	Baseline Ship
Light ship weight	16,000 MT	15,240 MT
Deadweight, maximum	29,900 MT	30,600 MT
Deadweight, design	20,700 MT	21,400 MT
Container Capacity	1,973 TEU	2,036 TEU
RO/RO Area (in container mode)	1,360 sq. M	4,140 sq. M

An arrangement of this ship appears in figure 4.

3.1.2 Shelter Deck Ship

This arrangement has watertight subdivision bulkheads extending only to the second deck, allowing the entire second deck area to be open for RO/RO movement and stowage. Structural bents and partial bulkheads carry the structural continuity to the main deck. These, along with stanchions at mid-hold and ventilation equipment required for RO/RO operations, will still offer some interference to RO/RO cargo movement and stowage. Principal dimensions of the shelter deck ship are as follows:

Length overall	206.0 M	(675.8 ft.)
Length between perpendiculars	194.0 M	(636.5 ft.)
Beam, molded (PanaMax)	32.2 M	(105.6 ft.)
Depth, molded	19.2 M	(62.8 ft.)
Draft, maximum	10.5 M	(34.4 ft.)
Draft, design	9.2 M	(30.2 ft.)

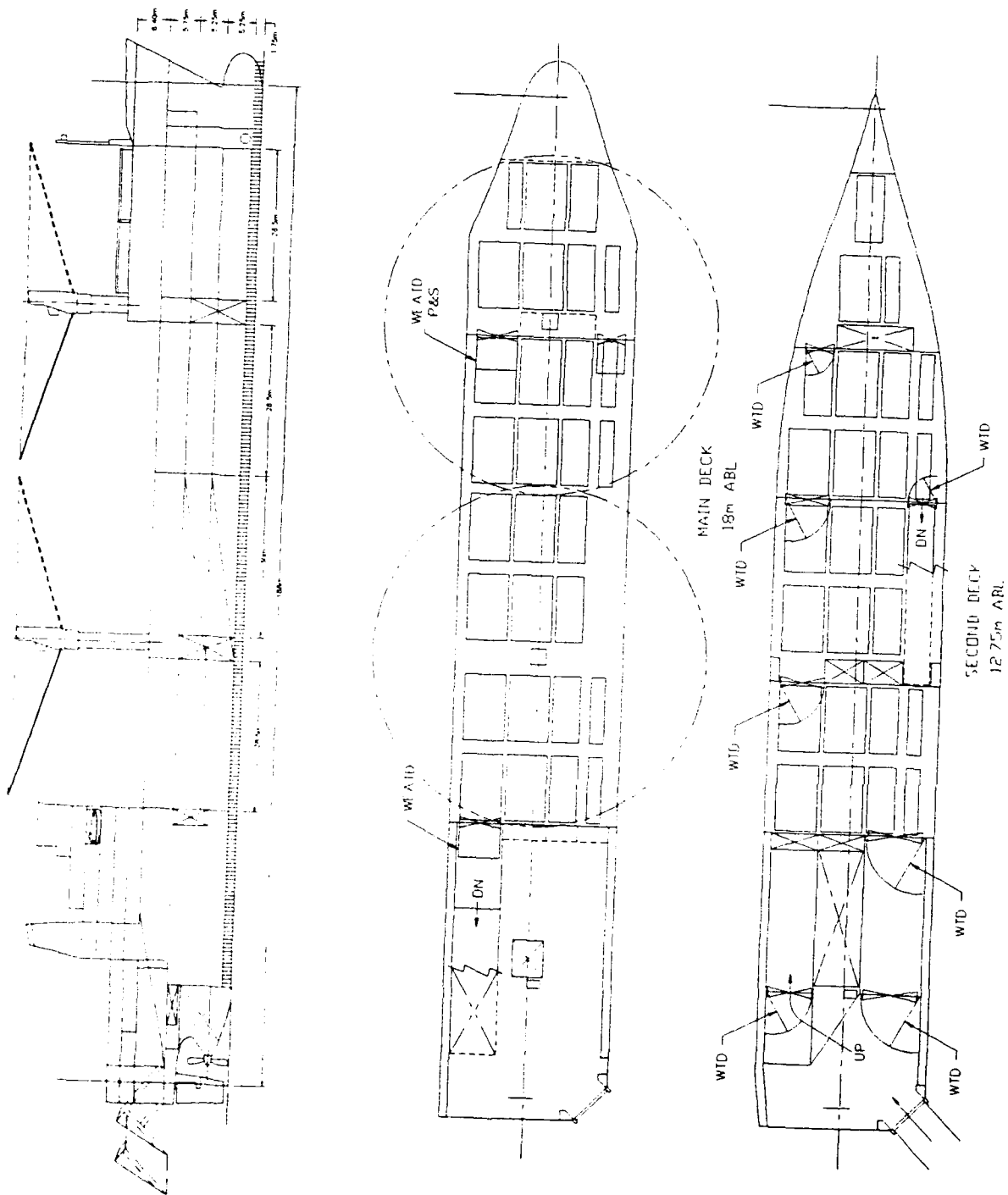


Figure 4: Full Scantling Ship

Light ship weight	16,900 MT	(16,600 L.T.)
Displacement, maximum	44,700 MT	(44,000 L.T.)
Deadweight, maximum	27,800 MT	(27,400 L.T.)
Cargo Deadweight, maximum	24,400 MT	(24,000 L.T.)
Displacement, design	37,900 MT	(37,300 L.T.)
Deadweight, design	21,000 MT	(21,000 L.T.)
Cargo Deadweight, design	17,600 MT	(17,300 L.T.)
Fuel oil, bunker "c"	3,000 MT	(2,950 L.T.)
Diesel oil	200 MT	(197 L.T.)
Fr. water, stores, crew & effects	200 MT	(197 L.T.)

Machinery and accommodations: Same as PD-337

Cargo Capacity: containership 1,973 TEU containers, and
1,360 sq.M (14,600 sq.ft.)
enclosed RO/RO area

Cargo Capacity: RO/RO 13,500 sq.M (145,000 sq.ft.)
enclosed area, and 2,500 sq.M
(26,600 sq.ft.) weather deck
area

Cargo Capacity: break bulk 52,900 cu.M (1,867,000 cu.ft)

Differences from the full scantling version are:

- A. Hull depth is increased, and maximum allowable draft is decreased, to provide sufficient freeboard to the second deck, which is now the freeboard deck. This increases cargo cubic capacity. Maximum deadweight is restricted because of the reduced draft.
- B. An additional tween deck is included, to utilize additional tween deck height created by the increase in depth. Although tween deck heights of this arrangement are reduced from those of the full scantling ship, a substantial amount of RO/RO stowage area is added.
- C. Ship length is increased, necessitated by the larger number of folded hatch cover panels at hatch ends than in the full scantling ship. The hatch cover panels are shorter, because of the reduced tween deck heights, requiring more panels to cover the same size hatch openings.

The slight increase in ship size does not increase its container capacity nor its deadweight. The major improvements are in the more open stowage arrangement in the upper tween deck and the increased RO/RO area from the additional deck. There is also a small increase in bale cubic capacity.

An arrangement of this ship appears in figure 5.

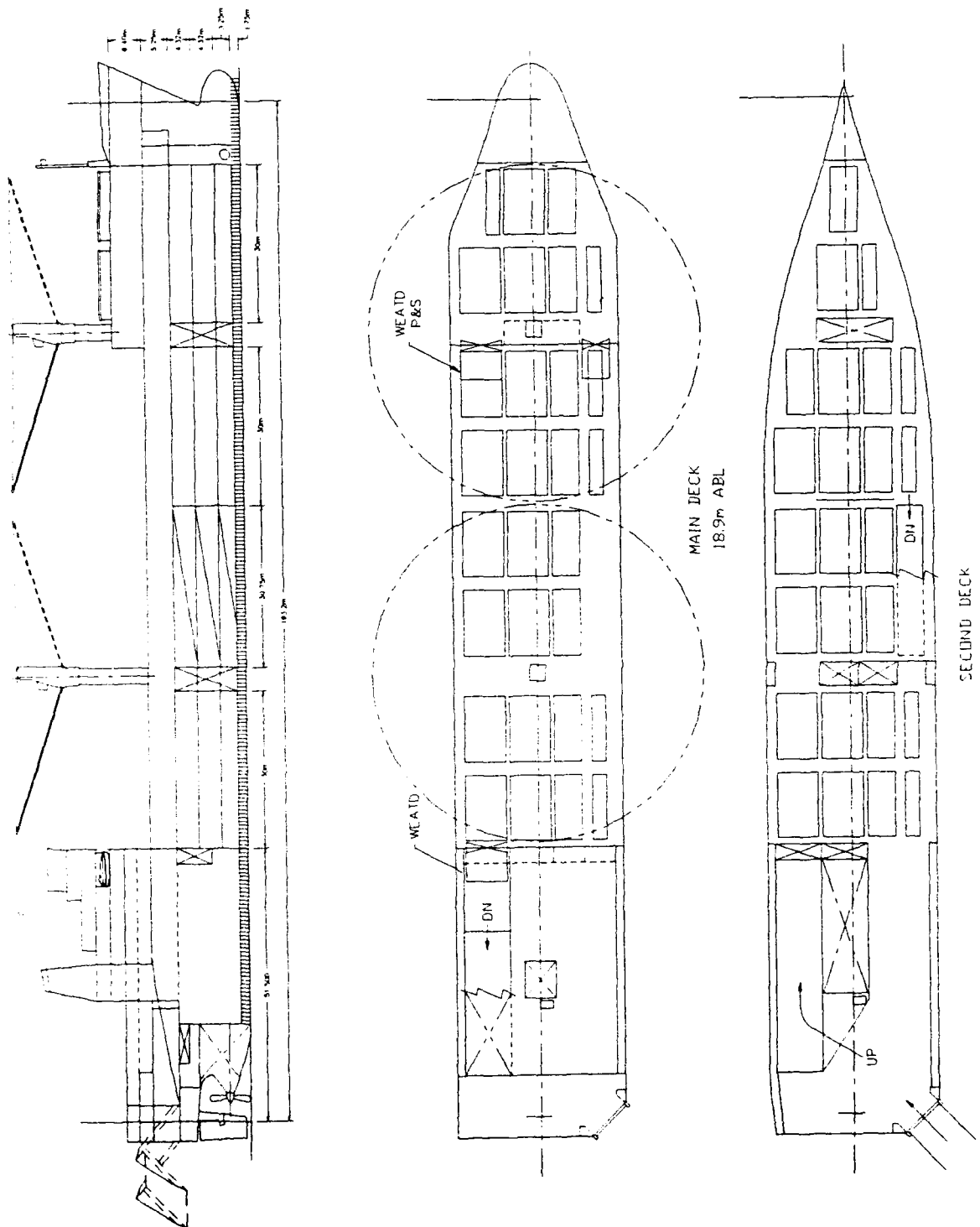


Figure 5: Shelter Deck Ship

3.2 RO/RO Operation

3.2.1 Requirements

The ship is designed to load vehicles of all types by driving them onboard across a ramp from the pier to a central staging area at the stern on the second deck, and from there to the cargo holds or the main deck. Unloading is done in a similar manner. It is expected that the vehicles will be military RO/RO when the ship is in U.S. Government service, although some commercial RO/RO trade may be offered when in commercial service. Some RO/RO cargo could be carried in the second deck stern staging area aft of hold 4 while the rest of the ship is carrying containers and/or break bulk.

3.2.2 Stowage Areas and Capacity

When parking vehicles, deck area is a more meaningful term than cubic capacity. Therefore, Ro/RO cargo capacity is given in terms of area of deck (square meters or square feet) available for RO/RO parking. This includes area occupied by ramps. At this conceptual stage of design, areas are taken as the molded deck areas in the spaces concerned, less 10% allowance for structure and other interferences. Figures are given as calculated. They are only approximate, considering the preliminary nature of this study. Internal ramp areas are included in the areas of the decks at the lower ends of the ramps.

A. Full Scantling Ship

<u>Space</u>	<u>Parking Area</u>	<u>Headroom</u>
Tank Top Hold 2	577	4.37 M (14'-4")
" " " 3	804	4.37 M (14'-4")
" " " 4	762	4.37 M (14'-4")
Sub-total Tank Top	2,143 sq.M	4.37 M (14'-4")
3rd Deck Hold 1	333	4.37 M (14'-4")
" " " 2	765	4.37 M (14'-4")
" " " 3	821	4.37 M (14'-4")
" " " 4	826	4.37 M (14'-4")
Sub-total 3rd Deck	2,745 sq.M	4.37 M (14'-4")
2nd Deck Hold 1	617	4.87 M (16'-0")
" " " 2	794	4.87 M (16'-0")
" " " 3	897	4.87 M (16'-0")
" " " 4	826	4.87 M (16'-0")
Stern staging area	1,360	4.87 M (16'-0")
Sub-total 2nd Deck	4,494 sq.M	4.87 M (16'-0")

Main Deck Hold 1	851 sq.M	5.94 M (19'-6")
Total Underdeck	10,233 sq.M	RO/RO stowage area
Weather Deck	2,367 sq.M	RO/RO stowage area

B. Shelter Deck Ship

<u>Space</u>	<u>Parking Area</u>	<u>Headroom</u>
Tank Top Hold 2	607	2.36 M (7'-9")
" " " 3	820	2.36 M (7'-9")
" " " 4	802	2.36 M (7'-9")
Sub-total Tank Top	2,229 sq.M	2.36 M (7'-9")
4th Deck Hold 1	239	3.43 M (11'-3")
" " " 2	795	3.43 M (11'-3")
" " " 3	831	3.43 M (11'-3")
" " " 4	869	3.43 M (11'-3")
Sub-total 4th Deck	2,734 sq.M	3.43 M (11'-3")
3rd Deck Hold 1	456	3.43 M (11'-3")
" " " 2	815	3.43 M (11'-3")
" " " 3	844	3.43 M (11'-3")
" " " 4	869	3.43 M (11'-3")
Sub-total 3rd Deck	2,984 sq.M	3.43 M (11'-3")
2nd Deck Hold 1	646	4.37 M (14'-4")
" " " 2	836	4.37 M (14'-4")
" " " 3	915	4.37 M (14'-4")
" " " 4	869	4.37 M (14'-4")
Stern staging area	1,360	4.37 M (14'-4")
Sub-total 2nd Deck	4,626 sq.M	4.37 M (14'-4")
Main Deck Hold 1	890 sq.M	5.94 M (19'-6")
Total Underdeck	13,463 sq.M	RO/RO stowage area
Weather Deck	2,468 sq.M	RO/RO stowage area

3.2.3 Technical Aspects

3.2.3.1 Arrangement of Cargo Spaces

A. Tween Decks

All decks are fixed. There are no adjustable car decks. Vehicles board the ship at the stern on the second deck, and either: (1) drive forward to the hold spaces on that same level; (2) drive down a system of ramps on the starboard side to lower

levels in the different holds; or (3) drive up a ramp on the port side to the weather deck.

(1) Full Scantling Ship Option

In the full scantling ship option, there are three cargo levels below the main deck, two tween decks and the tank top. The upper tween deck (or second deck), has 5.75 M molded deck height. The lower two levels, the lower tween deck (or third deck) and the lower hold, each have 5.25 M molded height. The depth of hatch side girder structure, based on American Bureau of Shipping (ABS) requirements, is estimated to be .88 M (2'-11") at all levels, assuming stanchions only at mid-hold in way of the hatch corners. This will provide a clear headroom of 4.87 M (16'-0") on the second deck, and 4.37 M (14'-4") on the lower tweendecks.

All three underdeck RO/RO levels will accommodate commercial highway trailers. All military RO/RO cargo, except the largest helicopters, is lower in height than highway trailers and will fit in these spaces. Helicopters will be stowed in a forecastle space with very high overhead clearance.

(2) Shelter Deck Ship Option

The shelter deck ship has a greater hull depth than the full scantling version, since the second deck is the freeboard deck. The second deck must be higher than that of the full scantling ship to ensure sufficient freeboard without severely limiting the draft. An additional tween deck is included to utilize the resulting additional tween deck height, thereby providing more parking area than the full scantling ship, however at varying deck heights. Assuming the same .88 M (2'-11") structural allowance at all levels, overhead clearances are as follows:

Location	Molded Dk Ht	Clear Headroom
Second deck	5.25 M	4.37 M (14'-4")
Third deck	4.32 M	3.43 M (11'-3")
Fourth deck	4.32 M	3.43 M (11'-3")
Lower hold	3.25 M	2.36 M (7'-9")

This arrangement, with the additional tween deck, is more efficient for military vehicle stowage, but it may have limited commercial RO/RO application, since highway trailer vans will only fit in the upper tween deck space (second deck).

B. Forecastle Deck

Large military helicopters are usually taller than commercial highway trailers. They will not fit below the main deck. The enclosed space beneath the forecastle deck is designed to accommodate these large helicopters. The largest helicopter requires slightly more than 19 feet overhead clearance in its static condition. Allowing 19'-6" clearance under the beams and

an additional 1'-6" structural allowance, the molded forecastle deck height is 21'-0" (6.40 M) above the main deck.

Note: These dimensions could be refined in the detail design stages, but the 19'-6" headroom will remain fixed. The hatch coamings above the forecastle deck could be used in combination with the underdeck girders to form the structural hatch side girders. This would decrease the required depth of girder below the deck. Stanchions should be restricted to mid-hold in way of the hatch corners, as in the underdeck structural arrangement.

The cargo space under the forecastle deck is but a small percentage of the total enclosed cargo volume. However, there are relatively few of the largest helicopters compared to the total volume of military RO/RO to be carried. Large helicopters would be lifted onboard by ship's cranes to the main deck and rolled forward through weathertight doors into the enclosed space. Smaller helicopters could be lifted onboard and lowered through the hatches for stowage in the tween decks. No helicopters would be stowed in the weather, nor would they be pulled onboard via the ramps.

C. Main Deck Stowage

Vehicles board the ship via the stern ramp and drive forward on the port side, up the ramp to the main deck at the forward end of the house. They can either stow in the weather or, if there is any additional space available after all helicopters are stowed, in the forecastle.

D. Helicopter Operation

The ship is arranged so that, in an emergency situation, all the helicopters carried may be flown off when the ship reaches its destination. There is a clear flush deck area over holds 2 and 3, which should be large enough for this purpose. No deck cargo could be stowed in this area at the time this was going on.

For this operation, the helicopters would either need to be transported from Stateside with fuel aboard, or be refueled prior to takeoff. Personnel would go aboard the ship at its destination to move the aircraft to the open deck, set up the rotors, refuel them if necessary, and otherwise make them ready for flight. When the aircraft are ready to take off all the cargo crane booms would be positioned to face away from the takeoff area. The high ship's forecastle would shelter the aircraft from headwinds until they are airborne.

This procedure is intended for emergency helicopter takeoff only. There are obstructions all around that will have to be avoided. High cargo cranes and ventilation trunks are at each end of the space, with almost 200 feet of clearance between them fore and aft. Container support pedestals, and perhaps ventilation trunks

line the sides of the ship fore and aft throughout the cargo hold area, leaving a clear width over the hatches of 88 to 98 feet. The rotors of all the helicopters (as listed in the military equipment information package given for this study) will be above the level of these obstructions at the time of liftoff, however whether there will be sufficient space for helicopter operations is a question that must be decided by the military.

3.2.3.2 Strength Requirements

Normally the strength of decks, hatches and ramps on a RO/RO ship is determined by: (1) Overall vehicle density in pounds of load per square foot of deck; and (2) Local point loadings from vehicle tires or tank tracks. Some of the military vehicles to be carried have a loading per square foot similar to that of loaded highway trailers (approx. 245 psf). Most are considerably greater, some over 500 psf.

Deck loading criteria for break bulk cargo in a high tween deck space can be higher than either military or commercial RO/RO requirements. Section 10.3 of the ABS Rules governing general cargo spaces requires an assumed average cargo density of 45 lbs./cu.ft., loaded to the underside of the overhead beams. The deck structure and hatch covers would have to be designed for 645 psf in the tween deck spaces where the clear height is about 14'-4", according to this criterion. In the spaces with greater deck height, design loading could even be greater. In the lower tween decks of the shelter deck ship, with reduced headroom, it would be less. This strength requirement is probably excessive for this type ship, considering that most modern cargos, even break bulk, are considerably lighter than 45 lbs./cu.ft. The RO/RO tweendecks, hatches and ramps will be designed for 525 psf as required by the military for RO/RO spaces. Unless required by the military for specialized, very heavy cargos, the main deck, hatch covers and ramp leading to the main deck will be designed for less severe loading than the tween decks. Fuel oil tank bulkheads exposed to RO/RO traffic will have heavy protective guards where necessary to prevent possible damage from vehicle impacts that could cause a fuel oil spill in the cargo spaces. Similar guards will be fitted elsewhere as required to protect any fittings or equipment exposed to possible RO/RO vehicle impact. A restriction will need to be placed on general cargo loadings in tween deck spaces with high headroom to prevent loading from exceeding 525 psf. Further analysis in this direction is beyond the scope of this project.

3.2.3.3 Ramps

A. General

Vehicles board the ship from the pier via a stern quarter ramp, entering a staging area at the aft end of the second deck. From there they have three ways to go for stowage:

- o Forward on the second deck into all the holds at that level, to the collision bulkhead. They have to pass through watertight doors at this level on the full scantling ship;
- o Down a system of ramps on the starboard side to the lower tween deck and lower hold. They must pass through watertight doors between holds at these lower levels on both arrangements;
- o Up a ramp on the port side, through a weathertight door, and forward onto the open main deck.

All ramps are to have non-skid ribbing. The heaviest military vehicle to be transported weighs 190,400 pounds. The widest is 12 feet. The highest, other than aircraft, is 13-1/2 feet.

B. Boarding Ramp

A standard commercial type hinged quarter ramp at the stern will provide vehicle access to the second deck from the pier, with the ship lying starboard side to. It will be actuated by wire rope rigging from elevated structures at the stern. It will be in two hinged main sections, which fold and stow vertically.

When outstretched, it will be long enough so that the maximum slope, with the ramp landed on the pier, will be limited to about 8 degrees during normal ship loading conditions and tidal range. Driveway width will be about 30 feet. Articulated dock "fingers" will smooth any pier-to-ramp irregularities resulting from ship list.

Depending on the type of boarding ramp chosen, the inboard section of the ramp may be used for watertight closure of the vehicle access opening in way of the ramp. This would eliminate the necessity for a separate watertight door in that space.

C. Tweendeck Ramps

(1) Ramps in Holds

There will be a system of fixed ramps in hold 3 on the starboard side, leading to the lower cargo spaces, arranged one above the other. It is necessary for the ramps to fit within the length of a single hold, to maintain one-compartment subdivision. Slope will be approximately 8 degrees, which is the practical maximum. Because higher tween deck spaces would require either longer or steeper ramps, and hold length is dictated by container size, 5.25 M tween deck space is a practical limit for RO/RO spaces in way of these ramps. Ramps will be 4.93 M (approximately 16 feet) wide to accommodate the widest vehicles (tanks). The design will facilitate installation and operation of watertight doors required in the main transverse bulkheads for one-compartment subdivision.

The spiral staircase arrangement, with one ramp above the other, is the least efficient for RO/RO operations. However, it will detract the least from the underdeck container capacity. For the ship to be attractive for commercial operation, it will need to maximize its container capacity, even at the expense of maximum RO/RO loading efficiency. The ramps are centrally located, fore and aft, so vehicles will have an entire hold at each end of their respective ramps in which to turn and double back.

The use of internal fixed ramps for RO/RO, instead of hinged or removable ramps, will reduce the costs of construction and maintenance and simplify operation and conversion. This is done with a loss of two 40-foot cells in way of the ramps, reducing the container count by 24 TEU.

The "instant convertibility" feature of this cargo handling concept would be seriously degraded if the ramps were to be made removable to retain the space for the two cells in the container mode.

A detailed investigation may prove that hinged ramps could be used, with integral hatch covers in the ramps. Preliminary study indicated that this concept was unworkable, but further work in this direction may be warranted.

(2) Ramp in Stern Staging Area

There will be a fixed ramp on the port side, within the stern vehicle staging area, leading forward and upward to the main deck. Vehicles may use this ramp to reach stowage positions under the forecastle deck, or in the weather on the main deck. Vehicles could also be stowed on the ramp itself, or in the stern staging area. These vehicles would be the last to drive on and the first to drive off. RO/RO, or other types of cargo handled by lift truck, could also be stowed in the stern staging area during container handling operations.

Supporting structure under this ramp should be kept as clear as possible. The space under the ramp on the second deck will be utilized for stowage of portable cargo handling fittings not in use in any given cargo handling mode.

3.2.3.4 Watertight Subdivision

A. Bulkheads

The ship is designed to a one-compartment standard of subdivision. Watertight bulkheads extending up to the freeboard deck separate the holds and the other watertight compartments.

The freeboard deck is the main deck on the full scantling ship arrangement and the second deck on the shelter deck ship arrangement. Watertight bulkheads extend only to the second deck on the shelter deck ship, but structural continuity and hull

strength require that partial bulkheads extend through to main deck.

B. Watertight Doors

Watertight doors will be fitted as necessary in the watertight bulkheads in the RO/RO cargo loading areas, for vehicle access from the stern staging area to all cargo spaces. If the stern ramp itself does not have an integral watertight closure, then a separate watertight door will also be needed at the stern.

Except where otherwise noted, watertight vehicle access doors will have clear opening heights the same as that of the spaces served and clear opening widths the same as that of the cargo hatches, consistent with proper alignment of supporting structure. The stern door in way of the boarding ramp will have a clear opening width the same as that of the ramp driveway. The doors in way of internal ramps will have clear opening widths the same as those of the ramps.

All the watertight doors will be hinged type without sills. Retractable bottom seals will allow smooth vehicle transit through the doorways and provide the required degree of tightness when the doors are closed. Except in cases when ramp arrangements dictate otherwise, all doors will open against the flow of loading traffic, for maximum utilization of stowage space. Side-hinged doors are used where headroom limitations and interference with overhead structure would limit headroom of top-hinged doors, otherwise top-hinged doors are used to minimize interference with loading operations. Both types doors are industry standard, available in any size.

C. Weathertight Doors

There is very little difference in the design of watertight (WT) and weathertight (WeaT) doors. Both types must be of equal strength to the surrounding bulkhead structure and differ only as do the relative strengths of these bulkheads. WT doors are below the freeboard deck and must prevent leakage against the head of a flooded compartment. WeaT doors are above the freeboard deck, forming part of the vessel's watertight boundary, and must prevent water penetration through this boundary or into the vessel in any sea condition. These are merchant ship design criteria. More stringent requirements for WeaT doors may be necessary to meet military standards.

There will be a WeaT door on the main deck, port side, at the head of the ramp in the vehicle staging area, leading to the weather. Two WeaT doors are to be fitted on the main deck at the aft end of the forecastle, one port and one starboard, to provide access to the helicopter storage space under the forecastle. All three WeaT doors are to be the width of the outboard hatches, consistent with proper alignment of the supporting structure. They will be top-hinged and have no sills. Retractable seals

will be used to allow smooth vehicle transit through the doorways.

Construction will be industry standard, similar to the watertight doors.

3.2.3.5 Cargo Tie-Downs

All RO/RO stowage areas, including the weather deck, will have vehicle tie-down fittings throughout on which to secure the cargo for sea. An arrangement of these fittings, specifying their number and type, will need to be developed in a more detailed stage of design. In general, low-profile raised type fittings will be used on watertight and oiltight decks and tank tops. Although flush fittings would provide the smoothest surface for RO/RO movement, experience has shown these to be a source of high maintenance, while vehicles are able to drive around or over the low-profile raised type with no difficulty.

Patterned cutouts will be used as lashing sockets in nontight plating, rather than attached fittings. This maintains the smoothest driveway surface in the tweendecks. Care must be taken in detail design to provide structural compensation for the cutouts, such as heavier deck and hatch top plating if necessary.

Care must also be taken, when developing the arrangement of RO/RO tie-down fittings, to avoid interference with container-securing fittings. While there is latitude for compromise in the vehicle tie-down arrangement, container securing fittings must be positioned exactly as determined by the container arrangement, with no room for compromise.

Care must be taken in selecting tie-down fittings to ensure that those in container landing areas do not project above the level of the bottoms of containers in the space. Allowance must also be made for bulging and sagging of loaded containers.

All the fittings required are existing industry-wide standard commercial items.

3.2.3.6 Ventilation

A powerful mechanical ventilation system is required to clear vehicle exhaust gases during RO/RO loading and unloading. ABS Rules require that the air in each affected space be changed 6 times per hour.

The arrangement described below will provide a total of 40 sq. ft. supply and 40 sq. ft. exhaust ducting cross-sectional area for each of the larger holds, with an internal air speed of 1,500 ft/min. Somewhat less total duct area is required in hold 1. All ducts, fans, terminals, etc., will be kept clear of container cells and will minimize impact on RO/RO and break bulk handling and stowage.

Four supply ducts and four exhausts in each hold, with integral fans, will move the required amount of air. Below decks the separate ducts will serve different levels, with different arrangements required for the full scantling ship and the shelter deck ship.

The supply trunks for holds 2 through 4 will be cylindrical, 3.6 feet in diameter with mushroom terminals, located at the ends of the holds in the vicinity of the cargo cranes.

The exhaust trunks in holds 2 through 4 will be rectangular, 2.0 ft. x 5.0 ft., located at the deck edge P&S outboard of the hatches. The terminals will face outboard to force the exhaust gases away from the ship. The exhaust trunks will pass up through the inboard side of the main deck box girder port and starboard and turn outboard just beneath the level of the second tier of deck containers. The second tier stows outboard to the ship's side, whereas the first (lowest) tier stops one container short of the ship's side, forming a walkway along each side. This duct will have to be designed to stay within the confines of the walkways to allow convenient walking passage fore and aft.

If this arrangement of flat rectangular exhaust ducts outboard will seriously degrade the structure of the box girders, then the exhaust trunks can be similar to the supply trunks and located in the same general areas. Exhaust gases must still be directed to the side of the ship, to prevent the possibility of short-circuiting back into the supply trunks.

3.3 Containership Operation

3.3.1 Requirements

A. General

The ship will carry standard 40-ft. long by 8-ft. wide ISO containers in cells below deck. It will also carry both 40-ft.x8-ft. and 20-ft.x8-ft. containers lashed above deck.

Once holds are converted to carry containers, container handling is done in the conventional manner, requiring no cargo handling personnel below decks. Containers are loaded and unloaded vertically through the hatches, using ship's cargo cranes or shore gear. Loading and unloading of containers can be done as quickly and easily as on a standard cellular containership, so the ship should be commercially attractive.

Container handling will be exactly the same for the full scantling ship as for the shelter decker. Converting the shelter decker to RO/RO will take slightly longer than with the other arrangement, however, because of the additional tween deck hatch covers that have to be opened.

All cells are shown as 40 feet in this study. In the detail design stage, trade analyses may show a greater availability of 20-foot containers than anticipated. It is desirable to minimize the number of 20-foot cells with this cargo handling system because of the difficulties of fitting a convenient moveable cell guide system in those spaces. However, careful design of on-deck container hold-down points will allow spaces above deck to be fitted for both 20-foot and 40-foot containers. 20-foot containers can then be stowed anywhere on deck. Two 20 footers can also be connected end to end with standard fittings to fit in a 40-foot cell, if desired.

B. Container Stowage in Holds

Cells will extend from the weather decks, under the hatch covers, in a vertical line the full depth of the cargo holds. Rather than a fixed grid of continuous members as in cellular containerships, the cell guides will be in short movable sections, either mounted to the underside of tweendeck hatches, or on fixed or portable frames.

Below decks in holds 2 and 4, there will be 9 cells across, transversely, in 4 hatches. In hold 3, in way of the ramps, stowage is 8 across, as shown in figure 6. The outboard cells in hold 1 and in the lower levels of hold 2 are limited by the hull shape. In these areas 20-foot cells could be used where practicable. An alternative arrangement, in which holds 2 and 4 would have 10 cells across in four hatches, should also be considered. This would maximize container capacity, however it would reduce the width of the box girders at the deck edge. Because these box girders are major load bearing elements effecting longitudinal strength, a complete structural analysis would be required to determine if the alternate arrangement is viable.

C. Container Stowage on Deck

On deck, containers will be stacked tightly together, transversely, as close to the full width of the ship as possible. This will give an arrangement of 13 across over the holds, slightly less than the beam of the ship. The outboard rows are raised on pedestals to provide a walkway fore and aft on each side of the deck. In the fore and aft direction, on-deck containers will be in line with the container cells below. The height of container stacks is limited only by ship stability and visibility from the bridge. The container count given in Section 3.3.2 is based on the arrangement shown in figure 7.

Additional container stowage will be provided aft of the deckhouse. Unused superstructure deck areas, and a system of container support pedestals to keep the deck edges clear for personnel where necessary, will provide space aft for a number of containers. Mooring equipment, etc., can all be kept beneath this container stowage. This aft container stowage arrangement

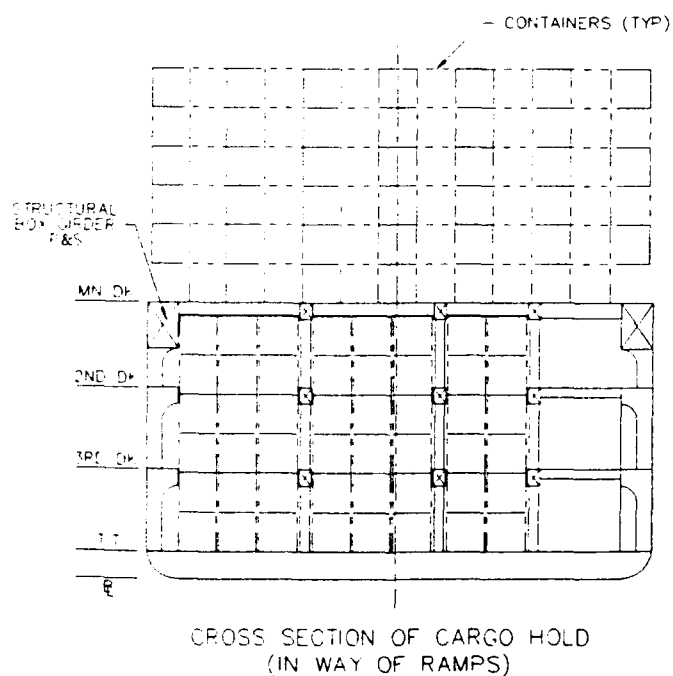
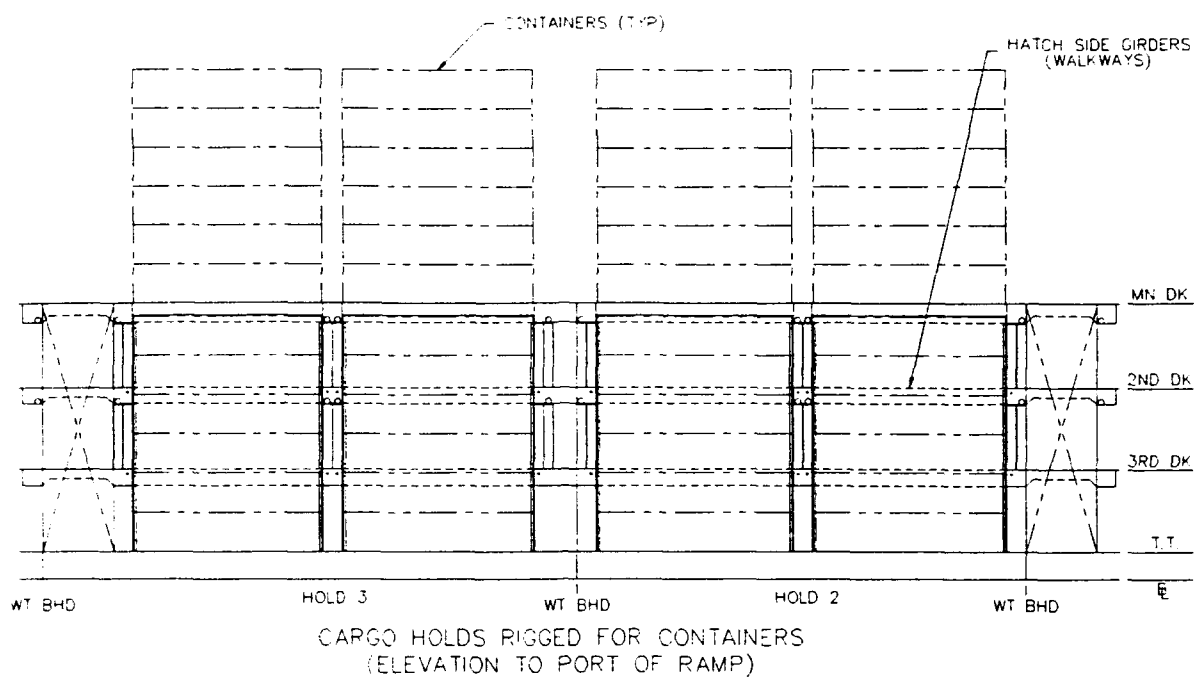


Figure 6: Cargo Hold Rigged For Containers

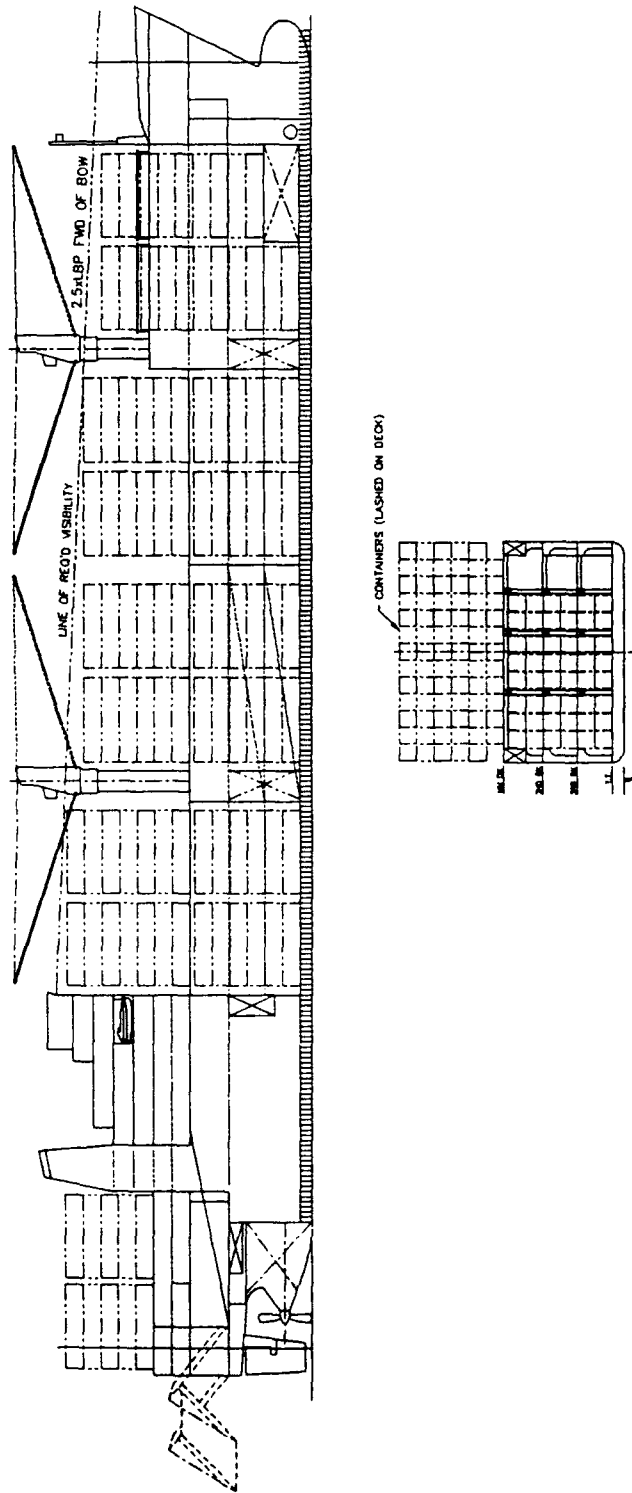


Figure 7: Container Loadout

can be designed around the structure necessary to raise and lower the boarding ramp. An accurate arrangement of this area cannot be made without a more detailed arrangement of the ship design. This will be done in the detail design stage.

3.3.2 Stowage Areas and Capacity

Containership capacities are normally given in "twenty-foot equivalent units" (TEUs), where one TEU refers to one 20-foot standard ISO container. Two TEUs are the equivalent of one ISO 40-foot container. The variation in container heights, which affects individual container capacity, is not considered. Maximum allowable gross weight of a 20-foot container is 20 L.T. (20.33 M.T.). Maximum allowable gross weight of a 40-foot container is 30 L.T. (30.49 M.T.).

Underdeck container capacity is fixed by the envelope of the hull and the hold arrangement. On-deck stowage capacity varies with the ship's stability and trim for each voyage. An average of heavier containers below deck and lighter containers topside would allow increased deck stowage and a greater number of containers overall. For this study, a maximum average container weight of about 18.6 M.T. (18.3 L.T.) is assumed for below-deck, and 10.16 M.T. (10 L.T.) for above deck. Container stowage on both the full scantling ship and the shelter deck ship is the same: 6-high in cells beneath the main deck (9-high beneath the forecastle deck), except where hull form interferes, and a maximum of 7-high lashed on deck. There is some wasted space under the hatch covers of the shelter deck ship because of the additional hull depth. However, there is not enough clearance to consider further increasing the height for another layer of containers. A breakdown of container capacities is as follows:

40-ft. Containers (FEU) in Cells Below Deck

Row	1	Hold	1	22
	2	"	"	54
	3	"	2	48
	4	"	"	54
	5	"	3	48
	6	"	"	48
	7	"	4	54
	8	"	"	53

Sub-total 381 FEU x 2 = 762 TEU below deck

TEU Lashed on Deck

Row	1	Hold	1	24
	2	"	"	36
	3	"	2	152
	4	"	"	152
	5	"	3	152
	6	"	"	152

7	"	4	178
8	"	"	178

Sub-total 1,024*

Stern 187

Sub-total 1,211 TEU above deck

Grand total 1,973 TEU

Additional 1,360 sq.M RO/RO area at stern 2nd deck

* On-deck TEU count based on visibility forward from the bridge to the water 2-1/2 x LBP forward of the bow at design draft and even keel. Other operating conditions may require a reduction in this amount.

3.3.3 Technical Aspects

3.3.3.1 Hatches

A. General

The ship will have an "all-hatch" arrangement, with hatches spaced as close together as possible to maximize container capacity in a vertical cellular system. All hatch covers and coamings at all levels except the forecastle deck will be flush with the surrounding deck plating to facilitate movement of RO/RO cargo. Forecastle deck hatches will be on raised coamings in the standard manner.

B. Weather Deck Hatches

On flush weather deck hatches, watertight seals will be incorporated into the hatch support structure below the deck level. Entrapped water will be diverted to bilge sumps or to scuppers leading overboard.

Weather deck hatch covers, including those on the forecastle deck, may be pontoon type as on most container ships, or they may be hinged panel type, opening fore and aft. Both have advantages and disadvantages regarding cargo handling.

Pontoon type covers are easiest to manage from a shipboard standpoint. They are lifted off the ship with the container handling gear when the holds are being worked, offering no interference with container movement at the hatches. On the other hand, they are in the way of shoreside operations while they are temporarily stored on the pier.

Hinged panel type covers do not clutter the pier, but they are an obstruction on deck, and could cause a decrease in productivity. Clear fore and aft opening between the raised hinged panels will

allow containers to be moved transversely between the panels and not be lifted over the top. However, this transverse movement between the upraised panels might have to be done more slowly and carefully than if the panels were not there. This could cause a productivity slowdown.

Preferences of the intended commercial operators should be a factor in deciding what type of weather deck covers to use. Except for the requirement to be flush, the type of weather deck hatch covers chosen does not affect the subject concept and will not be further addressed herein.

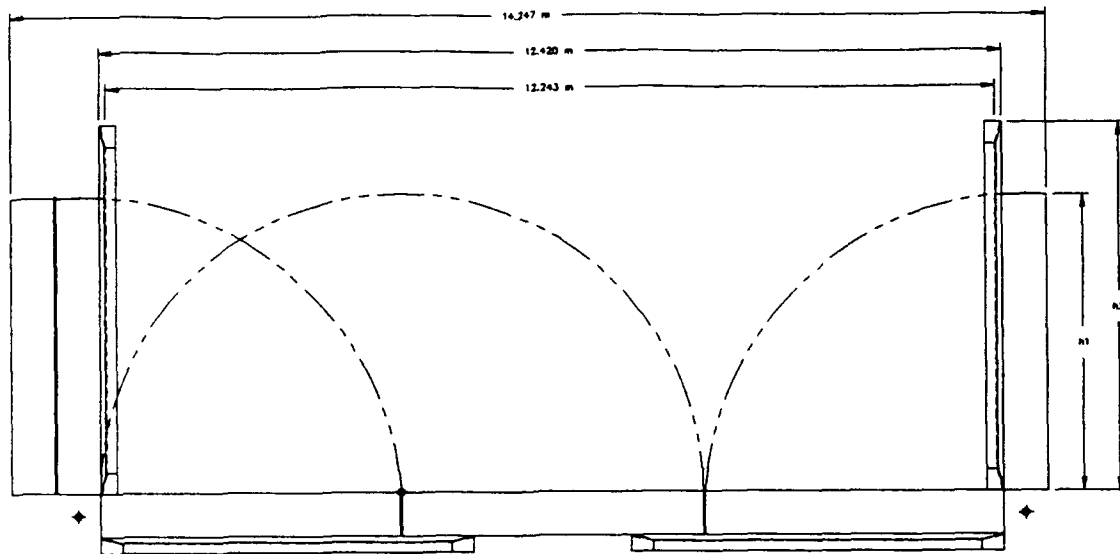
C. Tween Deck Hatches

Tween deck hatch covers are hinged panel type, opening fore and aft. Panels are sized and hinging arranged so the panels stand open in a vertical position with a fairly close fit beneath the overhanging structure, with the underside of the end panels (to which the deck hinges are attached) facing into the hatchway.

Hinging and actuation are different from that of folding hatch covers currently in use. Conventional covers open in an accordion-fold manner, with all hinges articulating in unison and the intermediate panels rolling toward the hatch ends along tracks at hatch sides. The subject covers must be operated by first opening the intermediate panels 180 degrees, then opening the folded pair 90 degrees, such as shown in figure 8.

Figure 9 illustrates a workable method of opening and closing the hatches. A dedicated actuation system could be designed in the detail stage, if desired, however this would add to the complexity, cost, and required maintenance of the ship. Wire rope is the preferred method for this application because of reduced maintenance. Cargo whip actuation is slower than dedicated automatic hatch cover actuation systems, primarily because of hooking up and unhooking, however it is simple and inexpensive. The method shown would be a good low-cost option for conversion between container and RO/RO cargo handling, where opening or closing the tween deck covers is only done once, and maximum speed is not an important factor. If the ship is expected to have much break bulk operation, the tween deck covers will be opened and closed continuously in port. Automatic actuation will then be desirable for the tween deck covers. In either case, if hinged type hatch covers are used for the weather deck, automatic actuation is desirable.

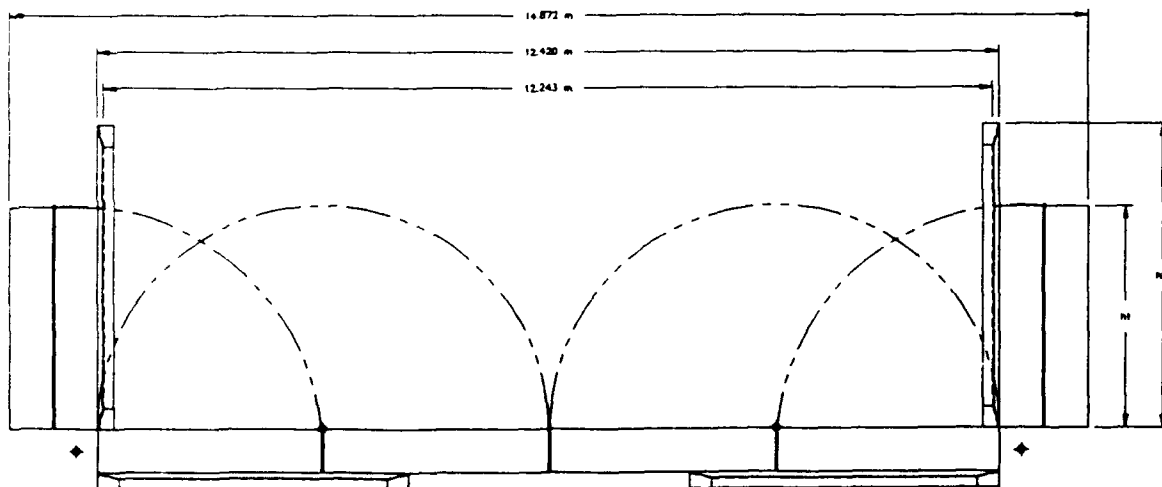
The tween deck hatch covers will remain locked open during the entire time the ship is in container operations. Only the weather deck covers will be opened and closed regularly. When open, the hatch covers will be locked with positive means to ensure correct spacing between facing panels, with correct cell guide alignment, and to provide sufficient rigidity to resist horizontal container loads in a seaway. This is expected to prevent the problems encountered by Moore McCormack Lines, Inc.,



h_1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD
(MINIMUM 4.140m, MAXIMUM 6.210m)

h_2 = VERTICAL DISTANCE BETWEEN DECKS
(MINIMUM $h_2 = h_1$, MAXIMUM 6.210m)

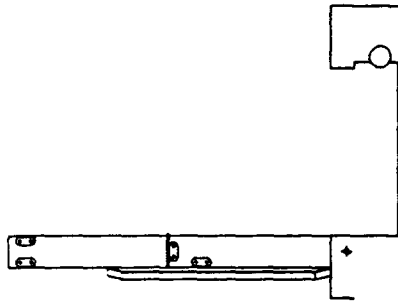
NOTE: IF HATCH IS TO REMAIN OPEN WHEN HATCH
ABOVE IS CLOSED, $h_2 = h_1$.



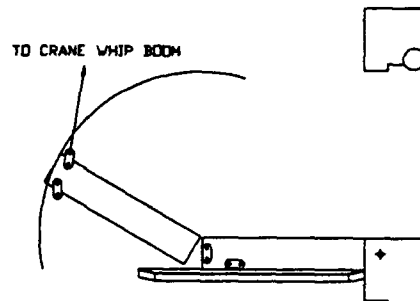
h_1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD
(MINIMUM 3.105m, MAXIMUM 6.210m)

Figure 8: Folding Hatch Covers With Container Guides

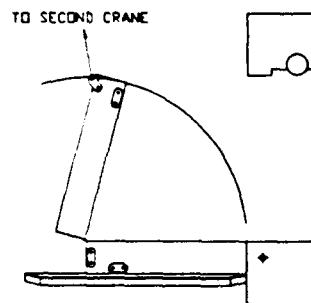
① HATCH IN LOWERED
(RO-RO) POSITION



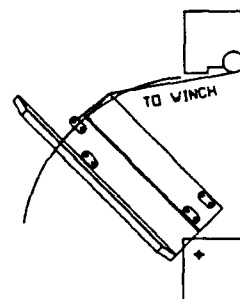
② LIFTING MIDDLE
HATCH SECTION



③ LOWERING MIDDLE
HATCH SECTION



④ LIFTING HATCH
SECTIONS



⑤ HATCH IN STOWED
(LO-LO) POSITION



Figure 9: Folding Tweendecks Hatch From RO/RO To Container Stowage Position

on their C5-S-78a RO/RO-Containerships. Details of the locks are beyond the scope of this study, but a workable system could be as follows.

Heavy steel pins are fitted at all four corners of the hatch cover panels to which the container guides are fitted. They are retracted inside the panel structure when the hatches are shifted and extended into the ship's structure above and below when in the fully opened position. These pins will be strong enough to resist the fore-and-aft and athwartship seaway loads of the loaded containers, without transferring loads to the hatch cover hinges. Extension and retraction of the pins is by ship's service air-actuated ram or manual worm gear inside the hatch cover panel. The air pressure would retract the pins against springs while the cover is being positioned or closed. When the air is released the springs force the pins into place and lock the panel in position. Tapered pins and a close fit in the holes will ensure proper alignment of the cell guides. Ship's service air lines run throughout the cargo holds will facilitate the use of air-actuated locks, as well as pneumatic tools.

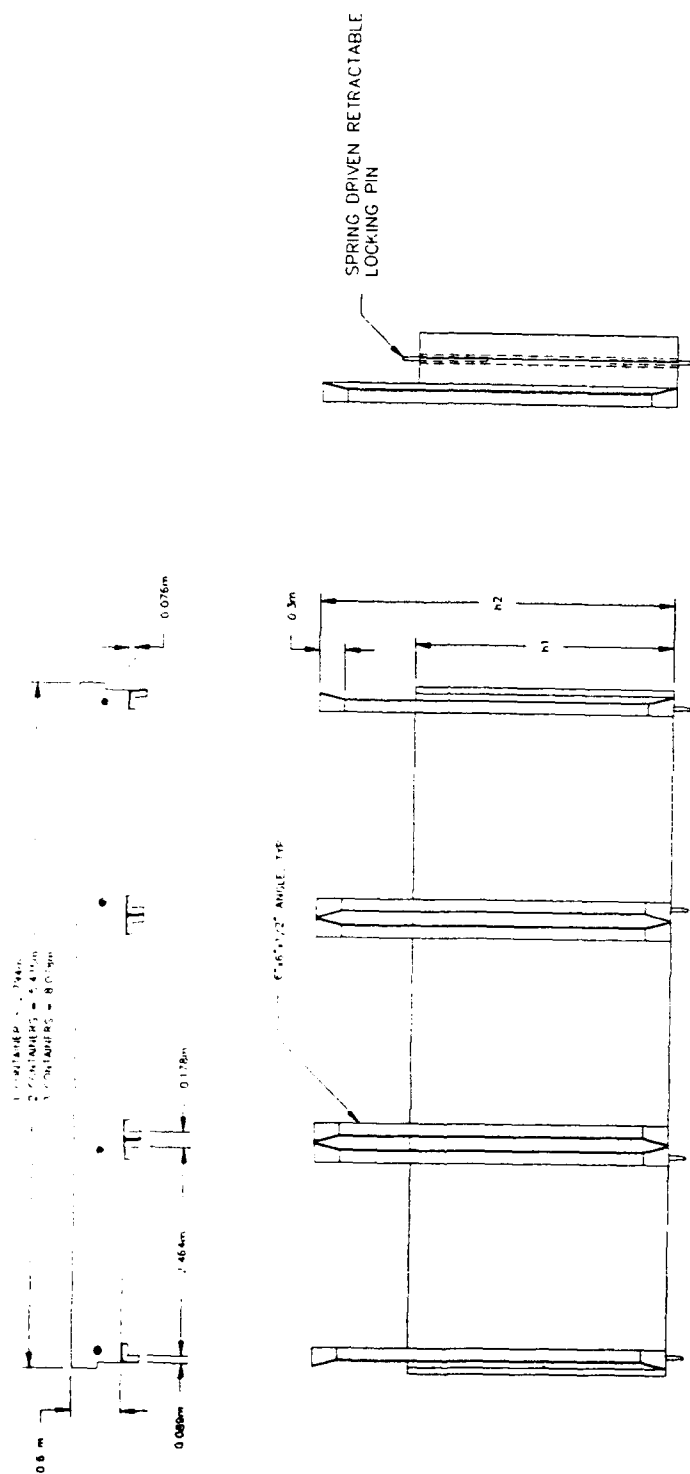
3.3.3.2 Container guides

A. Container Guides on Hatch Covers

Sections of 6"x 6"x1/2" steel angles are fixed to the underside of the hatch cover panels that face into the hatchway when open, as shown in figure 10. These form the container cell guides. Hinging details, hatch cover design and length of hatch openings in the structure must be precise to ensure the proper fore and aft distance between cell guides. Both ends of the guides will be flared to allow the containers to pass easily from one guide section to the next without hanging up. Below the second deck, the upper ends of the guides will be extra long, extending beyond the hatch cover panels to which they are attached. When the hatches are open these cantilevered sections extend upward and fill what would otherwise be gaps in the cell guide continuity. Once raised, the cantilevered upper ends are secured to the ship's structure by simple locks that will give the entire length of the guides their proper strength. This locking procedure will not necessarily have to be done in break bulk cargo handling.

The cell guide angles themselves will most likely have to be fitted on the hatch cover panels after the covers are installed on the ship and locked open to ensure proper alignment. The required degree of detail design is beyond the scope of this conceptual study, however, so a simplified generic schematic is shown to demonstrate the concept.

It is standard industrial practice to limit the maximum height of a container stack to 7 high, or to provide intermediate support. This limits the load on the lowest container in the stack and the supporting ship structure beneath. Container cells can exceed this height, but they must be fitted with moveable stops in the



$h1$ = VERTICAL DISTANCE FROM DECK TO OVERHEAD
 (MAXIMUM 6.210m)
 $h2$ = VERTICAL DISTANCE BETWEEN DECKS
 (MINIMUM $h2 = h1$, MAXIMUM 6.210m)
 NOTE IF HATCH IS TO REMAIN OPEN WHEN HATCH
 ABOVE IS CLOSED, $h2 = h1$.

Figure 10: Hatch Cover Panel With Container Guides

guides above the 7th container position. The stops are moved into position after the first 7 containers are loaded to take the weight of any additional containers. Container cells in this ship are 6-high except in hold 1, where the cells extend to the underside of the forecastle deck hatches. Here there are two 9-high cells and two 8-high cells. The guides on the main deck hatches at these cells must be fitted with the above-mentioned stops. The covers and guides must have sufficient strength to support the weight of the containers in question as well as the horizontal sea loads.

B. Container Guides in Lower Holds

(1) General

A container guide system will be fitted in the lower holds, between the tank top or other structure and the lowest tween deck, to complete the cellular continuity from top to bottom. The guide angles will be 6"x6"x1/2" steel angles, the same as on the tween deck covers. Tops will be flared, so containers can easily pass from one guide section to the next without hanging up.

Landing pads of approximately 4"x4"x1" plate will be fitted under the container corner landing points to provide local stiffening of the structure and to shim the corners where necessary so the bottom plane of each cell is square with its guides. These landing pads will be fitted at the 20-ft container corner landing points as well as the 40-ft corner points in way of the cell guides. Inner bottom framing or other structural reinforcement is arranged with strong points at these container landing corner pads. The pads will be permanently attached to the tank tops and should offer no hindrance to RO/RO.

Where a container cell is entirely over a flared part of the side shell, a structural pedestal will be built from the shell to a level where the bottom plane is square with the cell guides. This will not interfere with RO/RO stowage. It will, however, deduct some available break bulk cargo stowage volume, since that is calculated from the space inside the shell frames, not the deck area.

Where a container cell is partially over a flared area of the shell and partially over the tank top, a structural pedestal will be built over the shell and portable pedestals fitted on the tank top. This will provide the required elevated container landing corner without deducting from the available RO/RO area. The portable stands will be part of the portable container guide system. They will have to be individually designed for each separate location in the detail ship design stage.

(2) Portable Container Guides

Portable container guides will be employed in the lower holds in areas of RO/RO passage and stowage. These areas are basically in way of watertight doors between the holds and any other spaces blocked off from RO/RO stowage by container cells.

The guides will be arranged in modules, such as shown in figure 11. Modules will be the width of each hatch, and located at each end of the hatch, as on the tween deck hatch covers. Having them as large as possible minimizes the number of portable pieces to set up and take down. The modules will consist of a structural framework, with guide angles and locking pins attached. Strength and rigidity will be such that, when fixed to the ship structure at top and bottom, the modules provide the necessary support to restrain the loaded containers against seaway loads. They will weigh from approximately 900 lbs. to 5,000 lbs. each, depending on their size.

To erect the modules, they will be lifted into place and pinned into the ship structure above and below. The pinning arrangement and strength will be similar to that on the tween deck covers above, operated by air-pressurized rams and portable hoses or manual worm gear. As with the guides attached to the tween deck hatch covers, the upper ends of the guides on the portable modules will be extra long to fill in the gaps. The cantilevered ends will be locked to the structure the same as those on the hatch covers.

During RO/RO operations and possibly break bulk operations, the modules will be stowed in unused spaces by lift truck and cargo gear.

(3) Fixed Container Guides

Any location in the cellular grid not fitted with portable guides, or guides attached to hatch covers, will have fixed guides. This includes locations over flared sections of the side shell, or over the tank tops, but so close to other ship's structure that no appreciable RO/RO area is lost. There will be a very small amount of break bulk volume lost in these areas.

3.3.3.3 Cargo Cranes

Containers and vehicles too large to use the stern ramp, such as helicopters, will need to be loaded and unloaded by crane. Since shore based cranes may not always be available, especially in small or undeveloped ports, the ship will be provided with two twin-boom cargo crane sets. Gantry cranes are normally the preferred choice for handling containers (most shore based cargo cranes are gantry type), due to their higher container handling speed. Modern container gantry cranes, operated by skilled personnel, can move up to 30 containers per hour. An unmodified boom crane can move only six or seven containers in the same

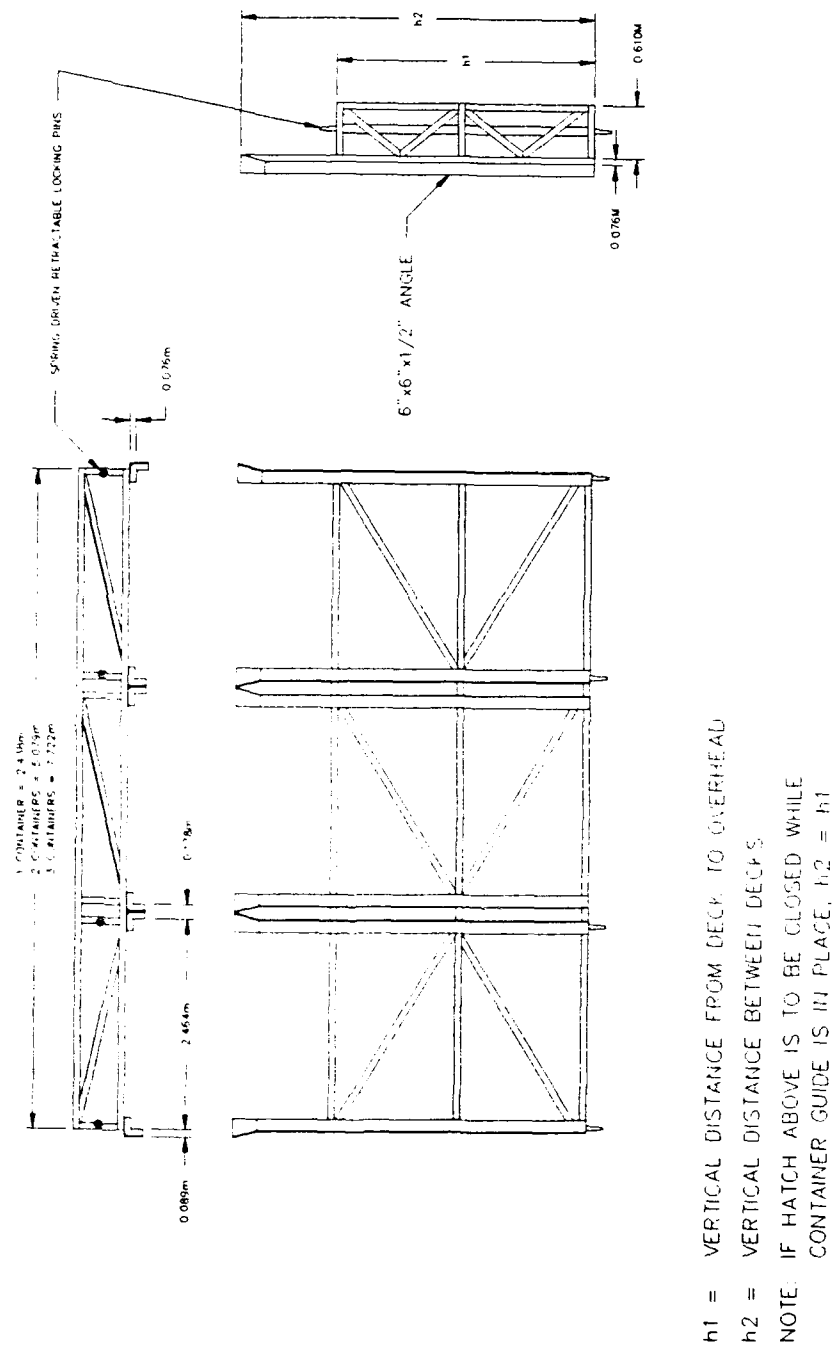


Figure 11: Portable Container Guide Module

time. However, while gantry cranes are used in some other trades, they are not applicable to all types of general cargo. Nor are they suitable for large items of military cargo, such as helicopters and floating causeways. On the other hand, boom cranes can be modified to more speedily handle containers, and still be used with any type of cargo.

The cranes will be positioned, and their booms will have sufficient outreach, to serve all cargo spaces, including the lifting centers of all container stowage positions (20-foot and 40-foot). Outreach will also be sufficient that the four booms working together will be able to launch a military floating causeway section.

Each crane set will have two independent booms, each having a lifting capacity of 30 long tons at maximum outreach. Two booms can be "married" (operated in tandem under the control of a single operator) for 60 L.T. lifts. All four booms can be used for up to 120 L.T. lifts, using strongback lifting beams. This maximum lifting capacity exceeds the weight of any military equipment being considered for transport on these ships, including the powered causeway.

Each boom will be equipped with a special container spreader with remote-control latching gear, for handling containers in the same manner as shore-based gantry cranes. The cranes will be level-luffing type, with sufficient capability to control rotation and pendulation of the spreaders, for precise positioning of the containers in the cells. This will provide the maximum container handling speed for this type of crane. Shoreside gantry cranes can also be used when available, for increased productivity. The ship's booms will be positioned out of the way at these times.

3.3.3.4 Container Tie Downs

A. General

There are no container tie downs below decks, or any other container restraining system below decks other than the cell guides.

There is an industry-wide standard system of fixed and portable fittings and lashings used to stack the containers on deck, on hatch covers and on each other. Container corners are restrained by special fittings which lock them to each other and to their deck stowage positions, to prevent shifting. Lashings are used to tie down stacked containers, in addition to the use of locking hold-down fittings.

B. Fittings

Watertight flush type container securing sockets will be used on this ship, rather than the standard raised pedestals common on container ships. This will entail extra maintenance, keeping

these flush fittings clean of dirt, debris and ice, but the raised type would interfere too much with RO/RO operations. Commercial portable twist-lock type stacking cones will serve to secure the containers to the hatch covers.

When containers are more than one high, they are lashed down as well as secured by their lower corners. Vehicle lashing padeyes, which lie flat when unused, can be used for securing container lashings, rather than the fixed raised pads now standard on containerships. Care must be taken in installation so the bottoms of the containers stacked on deck are higher than any raised RO/RO tie-down fittings in the container landing areas. Allowance must also be made for bulging and sagging of loaded containers.

3.3.3.5 Tween Deck Access

To maximize design container capacity within a given ship length, hold lengths are reduced to where open tween deck hatch cover panels occupy all the available space at the hold ends. There is no athwartship personnel access at any level in the holds where the hatches are open.

There are fore and aft walkways outboard of the hatches port and starboard. These are within each hold only at the lower levels. There will be personnel access watertight doors on the second deck, in way of the outboard walkways port and starboard, on the full scantling ship. Fore and aft passage between holds will be unobstructed on the second deck outboard on the shelter deck ship. To cross watertight transverse bulkheads between holds at lower levels, it will be necessary to climb to the second deck.

There are also narrow fore-and-aft walkways between hatches, on the hatch side girders, obstructed at midhold by stanchions. A person cannot walk the length of the hold on the walkways between hatches because of the stanchions. He can only approach the middle from either end.

All the fore and aft walkways are accessible from manholes and ladders to the main deck at each end of each hold.

3.4 Break Bulk Cargo Operation

3.4.1 Requirements

Break bulk cargo, also called general cargo, is loaded and unloaded through the hatches with the cargo gear. Oversize items are secured on deck in the weather. The cargo can be anything from boxes strapped to pallets (though items like this are generally now containerized), and rolls of paper to large pieces of machinery. The items are landed in the hatchway at the various levels and are moved by lift truck to their stowage positions.

Stowage is very labor intensive, and the longshoremen pack the cargo tightly to prevent shifting at sea. This puts the most cargo practicable into any given space. Hence, the 45 lbs./cubic foot criterion for deck structural design previously discussed in Section 3.2.3.2. On conventional break bulk ships, cargo is stowed up to the overhead in tween decks of moderate height. The heaviest and bulkiest items are stowed in the lower holds, where there is usually more headroom.

As noted earlier, a height/weight restriction will have to be placed on tween deck break bulk cargo stowage to avoid unnecessarily heavy structure in the tween decks. This detail must be negotiated between the ABS and the intended commercial operator during the detail design stage.

3.4.2 Stowage Areas and Capacity

Break bulk cargo capacity is defined as bale cubic. It is calculated as useable volume inboard of the hull frames or bulkhead framing to the underside of the deck beams over. The entire cargo hold space, the forecastle and the stern RO/RO area are available for break bulk stowage, except behind fixed container guides. The stern RO/RO area must be loaded by lift truck via the boarding ramp. The holds will be loaded through the hatches with the cargo gear.

Capacities shown herein are approximate, considering the preliminary nature of this study. A breakdown of capacities in all stowage areas is as follows, given in cubic meters.

A. Full Scantling Ship

Tank Top Hold 1	542 cubic M
" " " 2	2,769
" " " 3	3,353
" " " 4	3,277
Sub-total Tank Top	9,941
3rd Deck " 1	2,076
" " " 2	3,406
" " " 3	3,754
" " " 4	3,610
Sub-total 3rd Dk	12,846
2nd Deck " 1	3,575
" " " 2	3,932
" " " 3	4,619
" " " 4	4,022
Sub-total 2nd Dk	16,148

Main " " 1	5,356
Total in holds	44,291 cubic M
Stern RO/RO area	6,623
Grand total bale cubic capacity	50,914 cubic M (1,798,000 cubic ft.)

B. Shelter Deck Ship

Tank Top Hold 1	459 cubic M
" " " 2	1,562
" " " 3	1,948
" " " 4	1,972
Sub-total Tank Top	5,941
4th Deck " 1	1,193
" " " 2	2,760
" " " 3	2,872
" " " 4	2,982
Sub-total Tank Top	9,807
3rd Deck " 1	1,890
" " " 2	2,831
" " " 3	3,017
" " " 4	2,981
Sub-total 3rd Dk	10,719
2nd Deck " 1	3,356
" " " 2	3,727
" " " 3	3,999
" " " 4	3,798
Sub-total 2nd Dk	14,880
Main " " 1	5,577
Total in holds	46,924 cubic M
Stern RO/RO area	5,943
Grand total bale cubic capacity	52,867 cubic M (1,867,000 cubic ft.)

3.4.3 Technical Aspects

Two items of additional equipment are needed, beyond what is required for RO/RO and containers, for handling general cargo. These are:

- (1) Standard cargo lifting hooks for the cranes, in a range of lift capacities; and
- (2) Cargo battens in the holds, on the side shell, and on bulkheads, where general cargo is expected to be loaded.

Hatches at all levels are opened and closed frequently in break bulk operations. If this type of cargo is to be carried to any great degree, a dedicated tween deck hatch cover actuation system, one faster than the cargo gear-actuated system shown in figure 9, will be highly desirable. This decision requires the assistance of the intended operator to solve in the detail design stage.

4. Conversion

4.1 Cargo Mode Conversion Process Description

4.1.1 General

The term "conversion" for this ship applies only to opening or closing hatches and shifting portable container guide modules when changing from one mode of cargo handling to another.

The subject study is of cargo handling systems only. It does not address the larger picture of the total ship design. Other factors which might be present in changing the ship from commercial (mostly container) to military (mostly RO/RO) service are not considered in this study.

The conversion process described herein is for a single hold amidships. The procedure will be the same for all other holds, allowing for variations in arrangement. The procedure will also be the same in either of the two ship arrangements, except for the greater number of tween decks in the shelter deck ship.

4.1.2 Conversion from Container to RO/RO

A. Portable Container Guides

Open the main (or forecastle) deck hatches. Lower a ship's service air hose and send personnel to the tank top. Attach a cargo whip to a portable container guide module. Unlock the cantilevered container guide upper ends from the structure. Apply air pressure to the locking pin assembly and unlock the module from the structure. Detach the air hose and lift the module off the ship to the pier or barge alongside for temporary stowage. Repeat for remaining modules in the hold.

Bring the modules back aboard to the second deck, port side, after the tween deck hatches are closed in that area. Stow them under the fixed ramp above the engine room, using a large fork

lift truck. Additional stowage will be available on the tank top in hold 1, which is inaccessible to RO/RO.

B. Tween Deck Hatch Covers

The lowest tween deck covers must be closed first, to avoid interference between the cantilevered upper ends of the attached container guides and the covers immediately over. Other than that, the procedure for closing all of them is the same.

Retract the locking pins to release the cover from the ship structure. Close the cover by reversing the procedure shown in Figure 9. Repeat for remaining hatch sections in the hold. Tween deck covers do not need to be locked in the closed position, since their own weight, hinges, and surrounding ship structure will hold them in position. However, the locking pins which hold the hatch covers in position for container operation could also be used to lock the hatch cover sections closed.

Six people are recommended for the above operating procedure, one at each outboard fore and aft walkway, and one at each end of each walkway between hatches. This will save time and effort by eliminating the need to climb to the main deck to go athwartships or to get to the other side of the mid-hold stanchions on the narrow walkways.

C. Doors

After the portable container guides are removed and the hatch covers are closed, all the interior watertight doors are opened. The watertight door at the boarding ramp and the weathertight cargo doors on the main deck will remain closed until cargo is to be brought aboard.

4.1.3 Container to Break Bulk

To change from container to break bulk service, the following will be required:

1. The tween deck hatch covers will be closed and reopened regularly, as required for vertical loading and unloading at the different levels.
2. The portable container guides in the lower hold should be removed, although this not necessary. Removing them would open up a little more cubic space for stowage and eliminate the possibility of damaging the portable guide modules with cargo.

4.1.4 Break Bulk to RO/RO

This procedure will be similar to the changeover from container to RO/RO, except for the following:

1. The portable container guides will probably already have been removed, eliminating that step.
2. Some or all of the tween deck hatch covers might already be closed, eliminating that step.
3. Door operating procedure will be the same as in Section 4.1.2.

4.2 Facilities Required

The entire operation can be done at any pier or quiet anchorage.

Portable ladders and lift trucks will be required, but these should be part of the ship's equipment and will be stowed aboard for general use any time. A deck barge will be needed alongside for temporary stowage of portable container modules, if the operation is done at anchor.

No other special facilities are required,

4.3 Manpower Required

The following manpower estimate is made on the assumption of changing from full container service to full RO/RO service. It is based on the minimum number of persons required to perform the changeover of cargo systems. No other activity is included.

4.3.1 Manpower Required To Convert One Hold

- 4 persons: starting on main deck - undog and raise hatch covers; then to lower hold - detach portable cell guides & hook up to crane whip for removal.
- 6 persons (same 4 plus 2): at successive tween deck levels, starting at the lowest level - unlock and close tween deck hatch covers, undog and open watertight doors in holds.
- 2 lift truck operators: on second deck - stow portable cell guide modules under ramp aft.
- 2 crane operators: remove portable guide modules from ship; later return them to second deck or tank top, hold 1; actuate hatch covers (optional).
- 2 persons: shore (or barge) gang for hooking-on and unhooking portable guide modules in temporary storage.
- 12 persons total in one hold

All the operations described above must be done sequentially. Adding more personnel in the hold will not noticeably speed up the operation. For instance, the only thing gained by having personnel at the various hold levels simultaneously will be the time saved climbing or descending vertical ladders. The portable container guides have to be removed first, followed by closing the hatch covers in the lowest tween deck. Then the watertight doors can be opened if desired. After that, the hatch covers on the next level up will be closed, and so on. This sequence is necessary to: (1) allow the portable container guides to be removed through the open hatches; and (2) avoid damaging the cantilevered sections of cell guides on the hatch covers by possibly closing down the covers over while the ones below were still in the vertical position.

4.3.2 Manpower Required to Convert the Entire Ship

Holds could be converted sequentially, using the same 12 persons for the entire ship. This, of course, would take four times longer than the time to convert one hold.

If it is desired to convert all the holds at once, the following personnel would be required:

24 persons: in holds (6 in each of four holds with same duties as in 4.3.1 above).

4 lift truck operators covering all holds.

4 crane operators " " "

2 shore (or barge) gang

34 persons total on ship

4.4 Time Required

It is estimated that the above-mentioned 12 persons could convert one hold in from 4 to 8 hours. The same personnel could therefore convert all the holds in from 16 to 32 hours of working time. Simultaneously converting all holds with 34 persons is estimated to take perhaps 8 to 16 hours. Delays with the cranes and lift trucks serving all holds simultaneously will reduce efficiency. For this reason, substantially increasing the number of persons on the job would probably not have an appreciable effect on the above estimated schedule.

5. Weight And Cost Analysis

5.1 Base Ship

An existing ship was used as a baseline for estimating light ship weights of the subject two ships in this study. It was felt that the subject estimate would be more accurate if based on an actual

similar ship, rather than on another preliminary study such as PD-337. The ship used was MarAd Designation C7-M-F145a, a combination container and RO/RO carrier with approximately the same dimensions, arrangements and machinery as both the subject ships and PD-337. Crowley Maritime Corp. is the owner. Three ships were built in Denmark from this design in 1984 and 1985. All three are currently in service: Sea Wolf, Sea Fox and Sea Lion. Figure 12 shows an arrangement of this design.

No spaces are convertible from one type of cargo handling to another. The cargo holds are arranged with a fixed cellular container guide system. There is a minimum of structure in the holds, other than that required for hull rigidity and container cell support, and no interior hatch covers. Weather deck hatch covers are on raised coamings. There are standard raised type container securing fittings on the hatch covers for stowage of containers on deck, and pedestals outboard P&S to provide a walkway under the containers. There is no forecastle, but there is a breakwater forward to protect deck-stowed containers from heavy seas.

There is a RO/RO area in the stern, on second deck, with a folding quarter ramp for boarding. The ramp forms the watertight doorway closure when raised.

There are two dedicated container gantry cranes which roll fore and aft the length of the cargo deck using tracks with rack and pinion drive P&S.

Main characteristics of this ship, of PD-337, and of the subject two ships are listed below for comparison:

Item	C7-M-F145a	PD-337	Full Scantling Shelter Deck	
LOA	196.0 M	199.8 M	200.0 M	206.0 M
LBP	183.0 M	188.0 M	188.0 M	194.0 M
B (PanaMax)	32.2 M	32.2 M	32.2 M	32.2 M
D at side	20.5 M	18.0 M	17.5 M	18.9 M
d max.	11.0 M	11.0 M	11.0 M	10.5 M
d design	9.1 M	9.2 M	9.2 M	9.2 M
Displ. max.	45,716 MT	45,900 MT	45,900 MT	44,700 MT
DWT max.	32,031 MT	30,600 MT	29,900 MT	27,800 MT
Displ. des.	38,096 MT	36,700 MT	36,700 MT	37,900 MT
DWT design	24,412 MT	21,400 MT	20,700 MT	21,000 MT
Power	19,900 BHP	29,350 BHP	29,350 BHP	29,350 BHP
(normal)				
Steel Wt.	8,899 MT	9,650 MT	9,500 MT	10,000 MT
Outfit wt.	2,682 MT	3,050 MT	3,900 MT	4,300 MT
Machy wt.	2,103 MT	1,830 MT	1,900 MT	1,900 MT
Margin	-	710 MT	700 MT	700 MT
Light ship	13,684 MT	15,240 MT*	16,000 MT	16,900 MT

* Rounded up to 15,300 in PD-337 report.

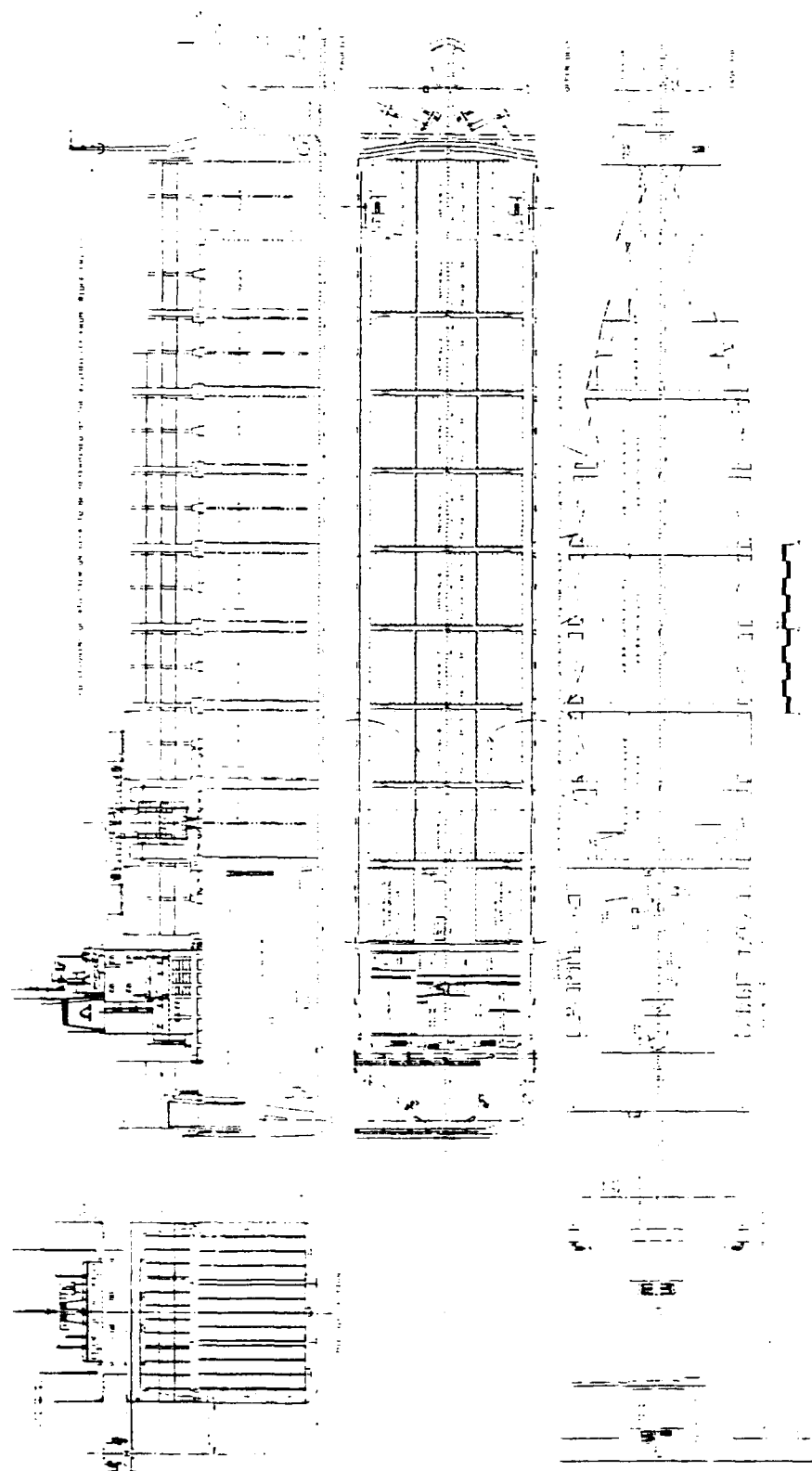


Figure 12: Arrangement of Crowley Maritime Ship (MarAd Design C7-M-F-145a)

5.2 Steel Weight

The steel weight estimates shown above for the subject ships are derived from:

- A. A ratio with the Crowley ship: $(c)(L)(B+D)$, where c is derived from the actual steel weight of the Crowley ship.
- B. A calculated addition for the forecastle structure.
- C. An estimated addition for extra tween deck and interior hatch cover support structure.

The steel weights are given in this section in English units to facilitate cost estimating. They are shown in metric units elsewhere for comparison with other ship designs. Totals are rounded up to be conservative.

	C7-M-F145a	Full Scantling	Shelter Deck
Basic hull	8,760 LT	8,600 LT	9,000 LT
Forecastle	--	200	200
Tween dks	--	500	600
Total	8,760 LT	9,300 LT (9,500 MT)	9,800 LT (10,000 MT)

5.3 Outfit Weight

5.3.1 Hatch Covers

The significant differences in outfit weight between the subject ship studies and the Crowley ship are from hatch covers alone. Other major items of cargo handling equipment which differ from the Crowley ship, such as cargo cranes, watertight doors and container guides, are not expected to have a noticeable impact on the weight estimate.

The hatch cover weight estimates are derived as described in the following. As with the steel weights, the figures are given in English units herein to facilitate cost estimating. Elsewhere in the report the total outfit weights are shown in metric units for comparison to other ship designs. Figures are rounded up to be conservative.

A weight for all hatch covers on the Crowley ship was calculated, using an average unit weight of 34 lbs/sq. ft., and subtracted from the total outfit weight. The remaining Crowley outfit weight was then multiplied by a ratio factor $(c)(L \times B)$ to obtain an estimate of the subject ship outfit weights, less hatch covers. Hatch cover weights were then calculated for the subject ships and added to the estimated partial outfit weights, for a total outfit estimate on both ship options. The hatch openings

and individual hatch cover weights are the same on both the full scantling and the shelter deck ships, even where the panel widths differ.

The estimate for tween deck covers on the subject ships is based on assuming a unit weight of 50 to 60 lbs/sq.ft. of hatch cover area, depending on the span of panel between supports. The tween deck covers must be designed for the heaviest RO/RO, as well as oversized break bulk loads, so their unit weights will be considerably greater than that of standard weather deck hatch covers.

The main deck covers will be carrying lighter than maximum RO/RO loads, so a unit weight of 45 lbs/sq.ft. is assumed. The forecastle deck will have standard weather deck covers at 34 lbs/sq.ft.

All unit weights as noted herein include actuation systems, where used, and miscellaneous attached fittings except container guides. Attached container guides are not included with hatch cover unit weights and are considered separately.

	C7-M-F145a	Full Scantling	Shelter Deck
Outfit wt.	2,640 LT		
Hatch cover est.	-500		
Outfit less hatch covers	2,140	2,200	2,300
Hatch cover est.		+1,500	+1,900
Outfit wt.		3,700 LT (3,800 MT)	4,200 LT (4,300 MT)

5.3.2 Cargo Cranes

There are two twin-boom rotating cargo crane sets similar to those specified in PD-337, except that they will have 30-ton lift capacity per boom instead of 40-ton capacity. Each boom will have a container spreader with remote latching gear and level-luffing, rotation and pendulation controls, along with the standard lifting fittings.

No details are available for either the PD-337 or the Crowley cranes, therefore no weight differential for cranes is considered justifiable in this order of magnitude weight estimate.

5.3.3 Watertight and Weathertight Doors

The large structural watertight and weathertight doors will weigh about as much as the sections of bulkhead they replace, since each type must have strength equal to the surrounding structure. They would be a small part of an overall detailed outfit weight

calculation, therefore no weight differential for this item is considered necessary in this order of magnitude weight estimate.

Watertight and weathertight doors are considered equivalent in strength and tightness requirements. They are listed as follows, for purposes of cost estimating.

Number and Type	Clear Opening Width Height	Ship Option
One: top hinged	25' x 19'-6"	Both
One: " "	25' x 14'-4"	Both
One: " "	17' x 19'-6"	Both
Seven: side hinged	25' x 14'-4"	Full sc.
Six: " "	" "	Sh. Dk.
Four: " "	16' x 14'-4"	Full Sc.
Five: " "	" "	Sh. Dk.

5.3.4 Container Guides

It is estimated that standard container cells have an additional 50% of backup structural weight in addition to the weight of the guide angles themselves (19.6 lbs/ft.). The guides on the underside of the hatch covers should have less than 50% backup structure. A reasonable figure for this would be 25%.

The portable modules are expected to have considerably more than the 50% added structural weight. An additional 150% of backup structure is estimated for these, which includes the trusswork to hold them rigid when disengaged and the locking gear described in Section 3.3.3.3. It is estimated that the modules will vary in weight from 900 lbs. to 5000 lbs. each, depending on their individual size.

The sum of the container guide system components for these ships should weigh very close to the same as a standard cell system in the same size ship's holds. The total weight of all the separate components is calculated to be no more than 200 tons. The difference in weight between this system and a standard arrangement would be very small. Therefore a weight differential would not be seen in this order of magnitude weight estimate.

5.4 Machinery Weights

The same weight for propulsive machinery as PD-337 was chosen for the subject ships, rounded up to be conservative. The machinery on the Crowley ship is heavier than that estimated for the more powerful MarAd machinery. MarAd advises they used a more modern main engine, with fewer cylinders and longer stroke, and sea water cooling vs. fresh water cooling. MarAd advises that these two factors account for the difference in the estimates. No further investigation will be made in this direction, because propulsion machinery is not part of this study.

5.5 Cost

Cost estimates are based on totals of steel, outfit and machinery weights, proportioned from the estimated costs of these items on PD-337. An additional 10% outfit cost allowance was included for special items that did not effect the weight estimate. These included ventilation for the RO/RO holds, watertight and weathertight doors, and ship's service air in the holds. The special container guide installation is considered comparable to the cost of a standard cellular grid. All other enhancements are included in the basic design weight estimates for the full scantling and the shelter deck ship. Estimated cost represent the average cost of each of 5 identical ships. Weights used in the estimate and the resulting costs are summarized below.

Item	PD-337 (baseline)	Full Scant- ling Ship	Shelter Deck Ship
Steel Wt:	9,650 MT	9,500 MT	10,000 MT
Outfit Wt:	3,050 MT	3,900 MT	4,300 MT
Machinery Wt:	1,830 MT	1,900 MT	1,900 MT
Steel Cost:	\$34.6 M	\$34.1 M	\$35.9 M
Outfit Cost:	\$57.0 M	\$80.2 M	\$88.4 M
Machinery Cost:	\$28.6 M	\$28.6 M	\$28.6 M
Engineering:	\$2.8 M	\$2.8 M	\$2.8 M
Total Cost: (baseline ship)	\$123.0 M	\$145.7 M	\$155.7 M
Enhancements:	\$37.0 M	\$0.0 M	\$0.0 M
Total Cost: (enhanced ship)	\$160.0 M	\$145.7 M	\$155.7 M

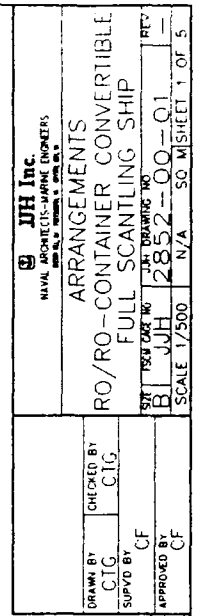
The estimated differences in cost between the subject ships and PD-337 are as follows:

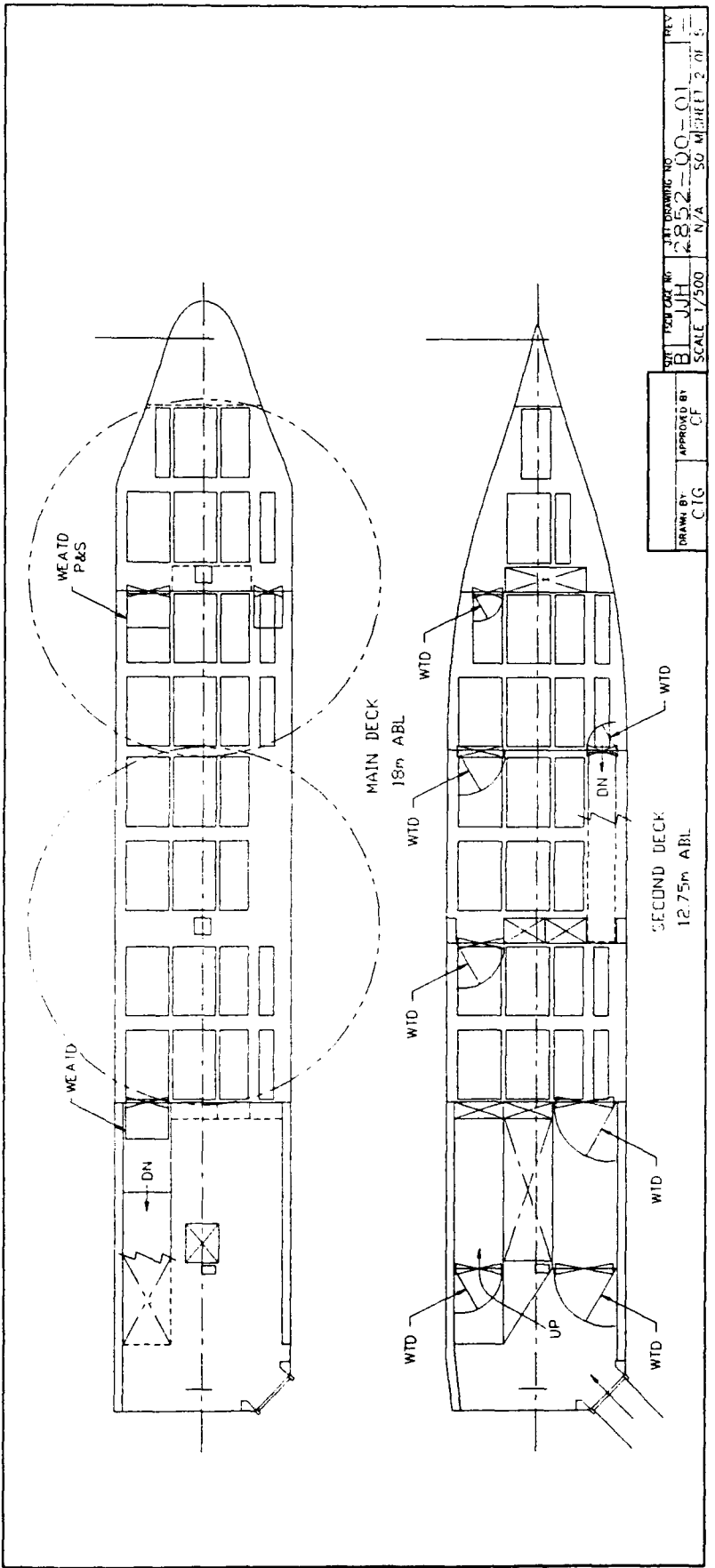
Full Scantling Ship - \$22.7 M more than PD-337 baseline
 \$14.3 M less than PD-337 enhanced

Shelter Deck Ship - \$32.7 M more than PD-337 baseline
 \$4.3 M less than PD-337 enhanced

DRAWINGS

<u>Drawing</u>	<u>Drawing Number</u>	<u>Sheets</u>
Arrangements RO-RO/Container Convertible Full Scantling Ship	JJH-2852-00-01	5
Arrangements RO/RO-Container Convertible Shelter Deck Ship	JJH-2852-00-02	4
Container Guide/Hatch Covers	JJH-2852-00-03	3
Container Guides - Portable	JJH-2852-00-04	2

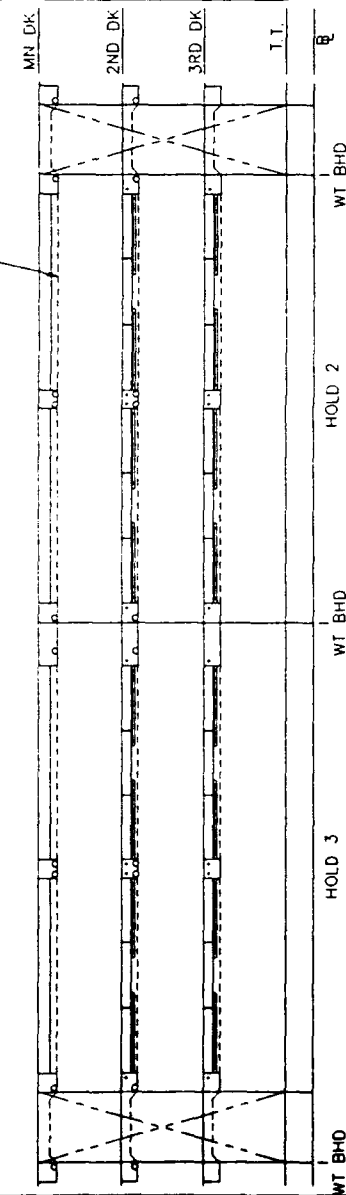




DRAWN BY		CIG		APPROVED BY		CF	
SYN		TWO COPY NO.		JIT DRAWING NO.		REV	
B		JH		2852-00-01		2	
SCALE		1/500		N/A		SO MARET 2 OF 3	

HATCH SIDE GIRDERS
(WALKWAYS)

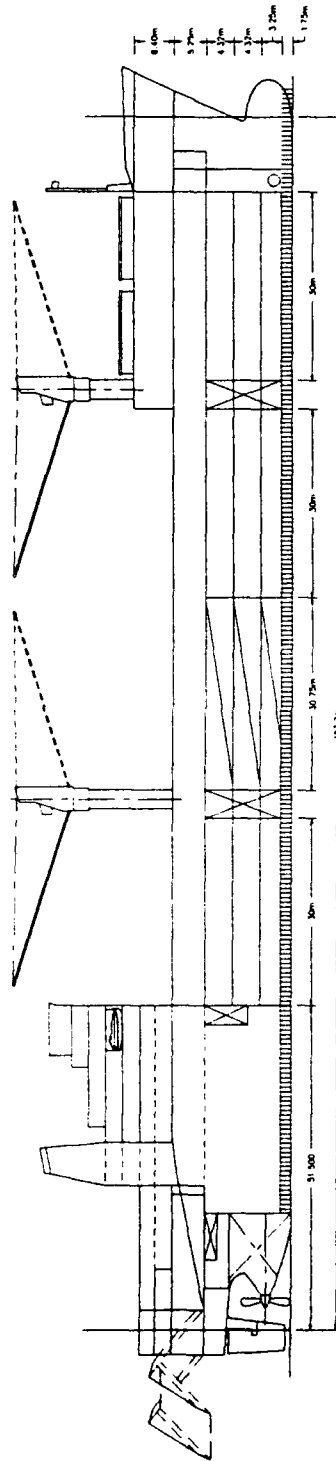
STRUCTURAL
BOX GIRDER
P&S



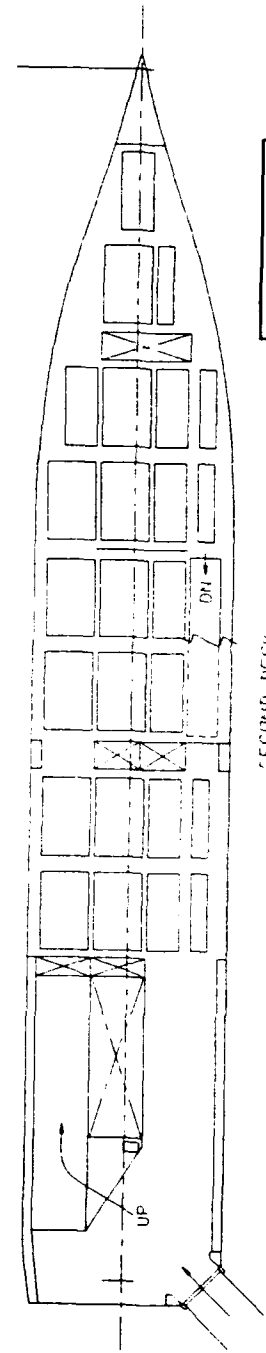
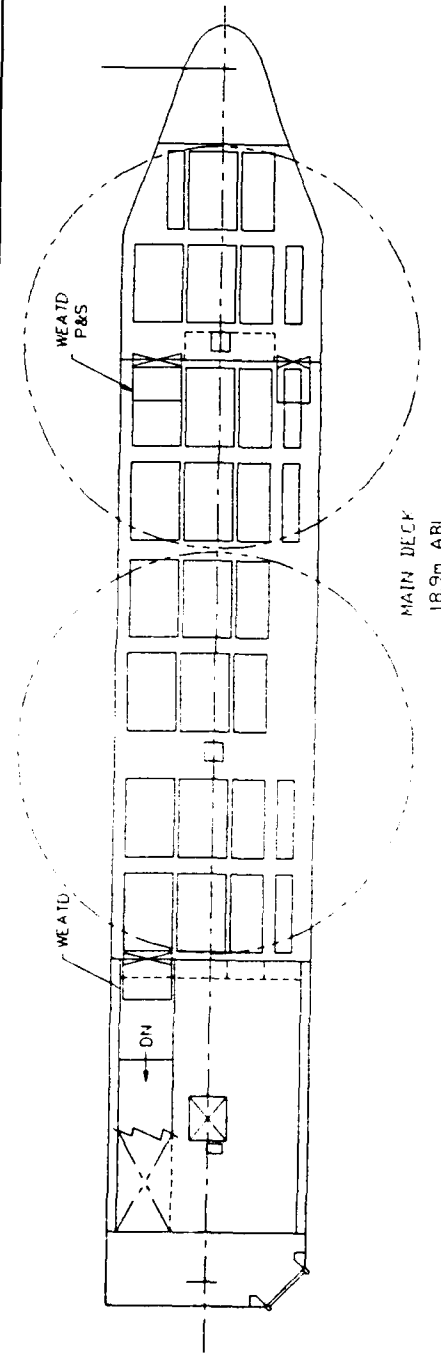
CARGO HOLDS RIGGED FOR RO/RO
(ELEVATION TO PORT OF RAMP)

CROSS SECTION OF CARGO HOLD
(IN WAY OF RAMPS)

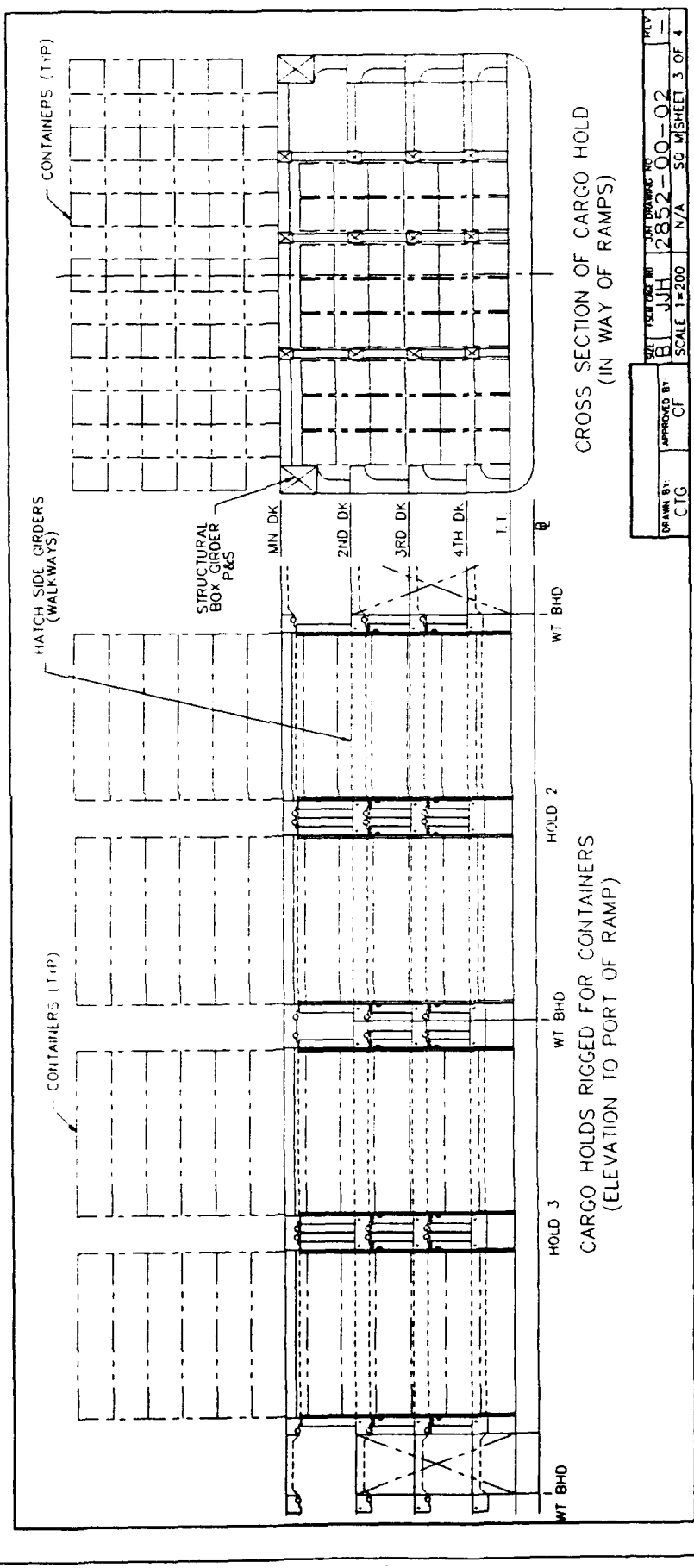
DESIGNED BY	CTG	APPROVED BY	CF	SHEET NO.	2852-00-Q1	REV	5 OF 5
SCALE		1=200		N/A		SU. MISHET	



JH Inc. NAVAL ARCHITECTS-MARINE ENGINEERS 1000 15th St. N. Suite 100 Minneapolis, MN 55403		ARRANGEMENTS RO/RO-CONTAINER CONVERTIBLE SHELTER DECK SHIP	
DRAWN BY: CIG	CHECKED BY: CIG	DATE: 1/20/02	NO. OF SHEETS: 2852-00-02
SUPV'D BY: CF	APPROVED BY: CF	SCALE: 1/500	REV: N/A
		SHEET 1 OF 4 SC WISHEET 1 OF 4	



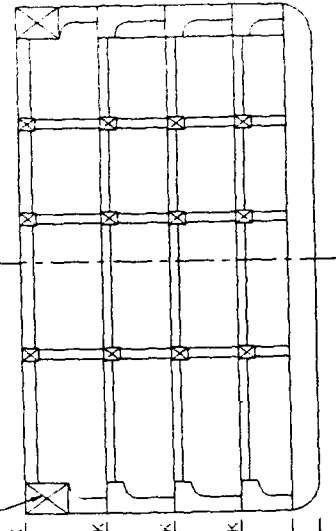
DRAWN BY CTG	APPROVED BY CF	DATE	TSR TAG NO	JAN DRAWING NO	PTS
		B	JJH	2852-00-02	
SCALE 1/500		N/A	SG MSHEET 2 OF 4		



DRAWN BY:	CF	APPROVED BY:	CF	DESIGN NO.	2852-00-02	REV	1	3 OF 4
SCALE	1"=200	N/A						

HATCH SIDE GIRDERS
(WALKWAYS)

STRUCTURAL
BOX GIRDER
P&S



CROSS SECTION OF CARGO HOLD
(IN WAY OF RAMPS)

HOLD 2

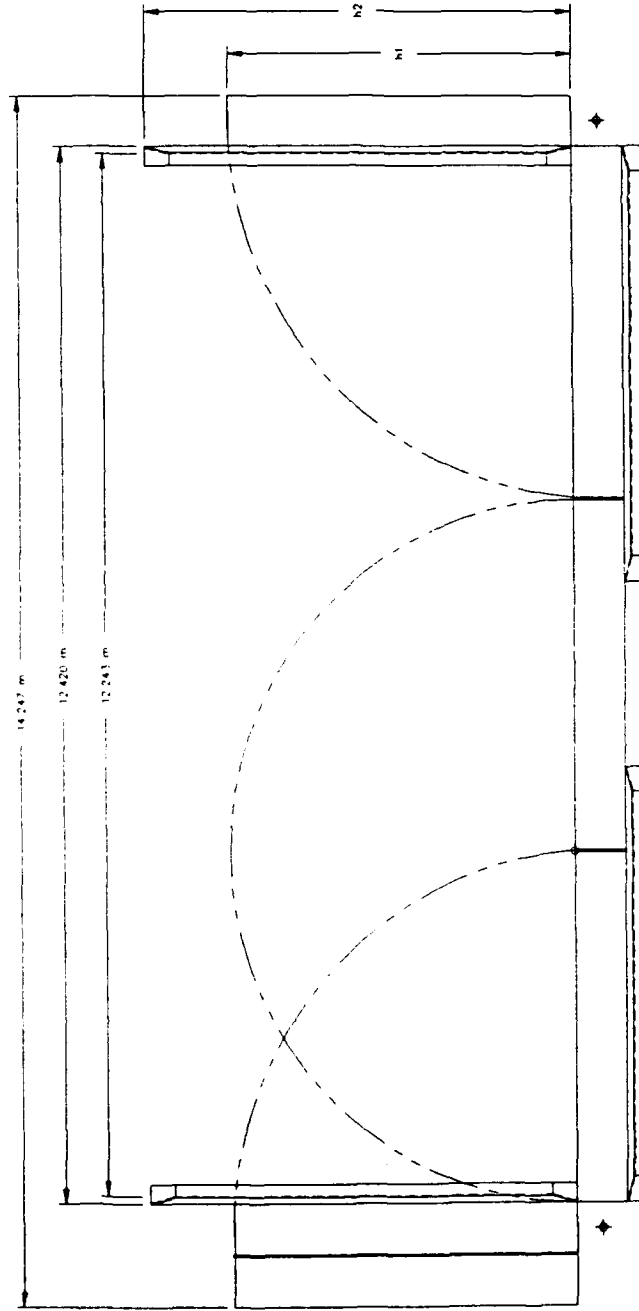
WT BHD

HOLD 3

WT BHD

CARGO HOLD RIGGED FOR RO/RO
(ELEVATION TO PORT OF RAMP)

DESIGNED BY	CTG	APPROVED BY	CF	DATE	28 JUL 80	DRWING NO	2852-00-02	REV	4
SCALE			1=200	N/A		SHEET		4	OF 4



h1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD
(MINIMUM 4.140m, MAXIMUM 6.210m)

h2 = VERTICAL DISTANCE BETWEEN DECK'S
(MINIMUM h2 = h1, MAXIMUM 6.210m)

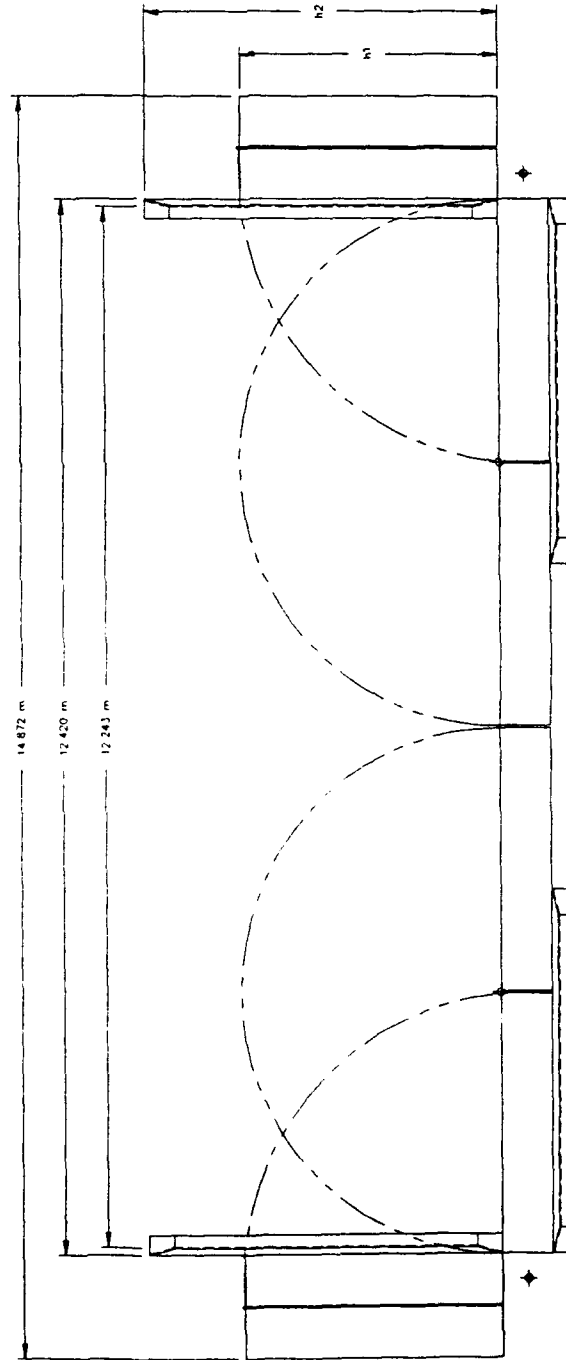
NOTE: IF HATCH IS TO REMAIN OPEN WHEN HATCH
ABOVE IS CLOSED, h2 = h1

JJH Inc.
NAVAL ARCHITECTS-MARINE ENGINEERS
OFFICE NO. 101 VERMONT ST. NEWTON, MA 02459-1010

CONTAINER GUIDE/
HATCH COVERS

SIZE	TSCH	CART NO	JJH	DRAWING NO	2852-00-03	REV	-
SCALE	1/20	N/A	SO	MISHEET	1 OF 3		

DRAWN BY:	C.T.G.	CHECKED BY:	C.T.G.
SUPVD BY:	CF	APPROVED BY:	CF



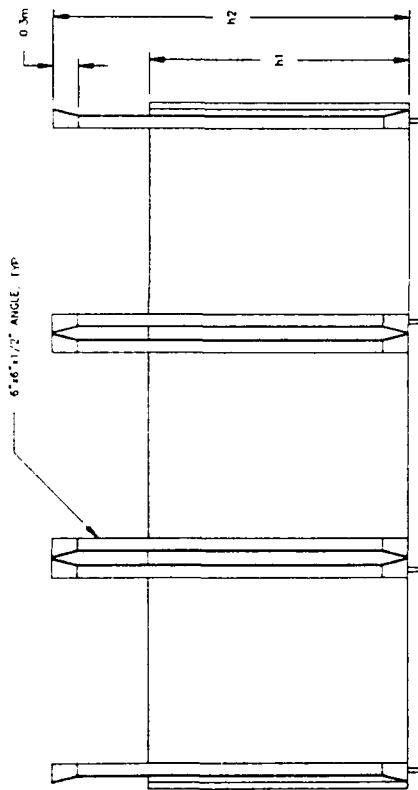
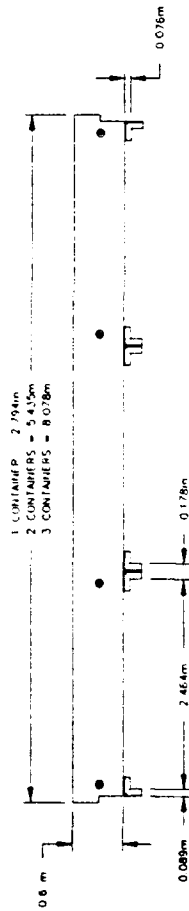
h1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD
(MINIMUM 3.105m, MAXIMUM 6.210m)

h2 = VERTICAL DISTANCE BETWEEN DECKS
(MINIMUM h2 = h1, MAXIMUM 6.210m)

NOTE: IF HATCH IS TO REMAIN OPEN WHEN HATCH
ABOVE IS CLOSED, h2 = h1.

DRAWN BY:	APPROVED BY:
CTG	CF

SIZE	FSM	CAGE NO.	JJH	DRAWING NO.	REV
B1	JJH	2852	-00-03		-
SCALE	1/20	N/A	SO	MISHEET 2 OF 3	



h1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD
(MAXIMUM 6.210m)

h2 = VERTICAL DISTANCE BETWEEN DECKS
(MINIMUM h2 = h1, MAXIMUM 6.210m)

NOTE: IF HATCH IS TO REMAIN OPEN WHEN HATCH
ABOVE IS CLOSED, h2 = h1.

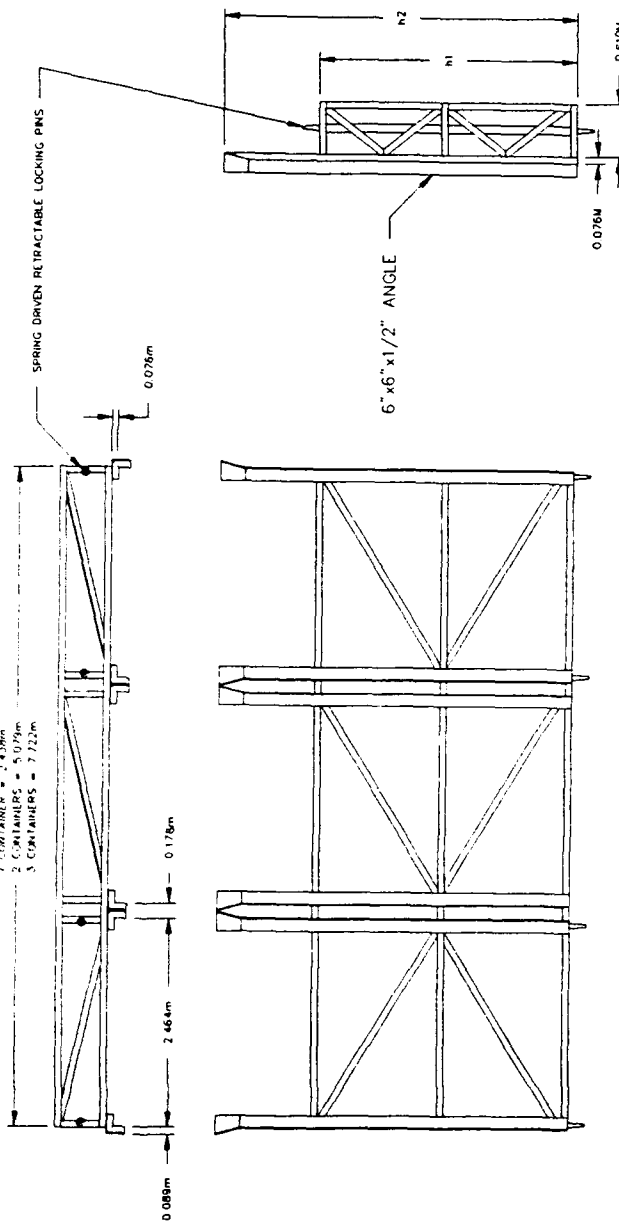
DRAWN BY:
CTG

APPROVED BY:
CF

SIZE: B JFH TSCW CQC NO: JFH DRAWING NO: 2852-00-03 REV: —

SCALE: 1/20 N/A SQ M/SHEET 3 OF 3

1 CONTAINER = 2.43m
2 CONTAINERS = 5.07m
3 CONTAINERS = 7.72m



h1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD
h2 = VERTICAL DISTANCE BETWEEN DECKS
NOTE: IF HATCH ABOVE IS TO BE CLOSED WHILE
CONTAINER GUIDE IS IN PLACE, h2 = h1.

JH Inc.
NAVAL ARCHITECTS-MARINE ENGINEERS
1000 N. 10th St. Suite 100
Annapolis, MD 21403

CONTAINER GUIDES - PORTABLE

DRAWN BY: CTG
CHECKED BY: CTG
SUPVD BY: CF
APPROVED BY: CF

SIZE: B
TSCM CASE NO.: JH
JH DRAWING NO.: 2852-00-04
SCALE: 1/20
REV: 1
SO MISHEET 1 OF 2

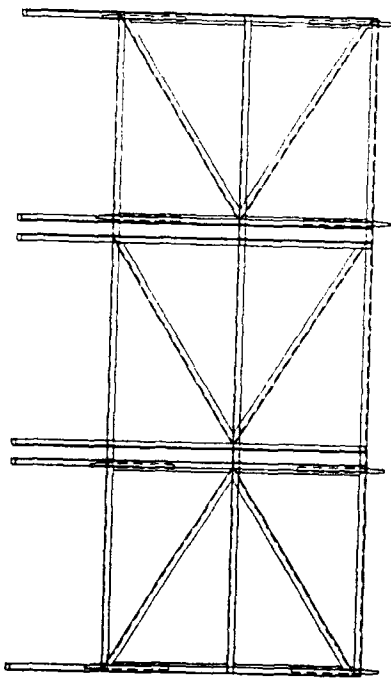
ALL FRAME MEMBERS 3"x3"x1/2" ANGLE



SPRING DRIVEN RETRACTABLE LOCKING PINS



GUIDE STIFFENERS
3"x3"x1/2" ANGLE

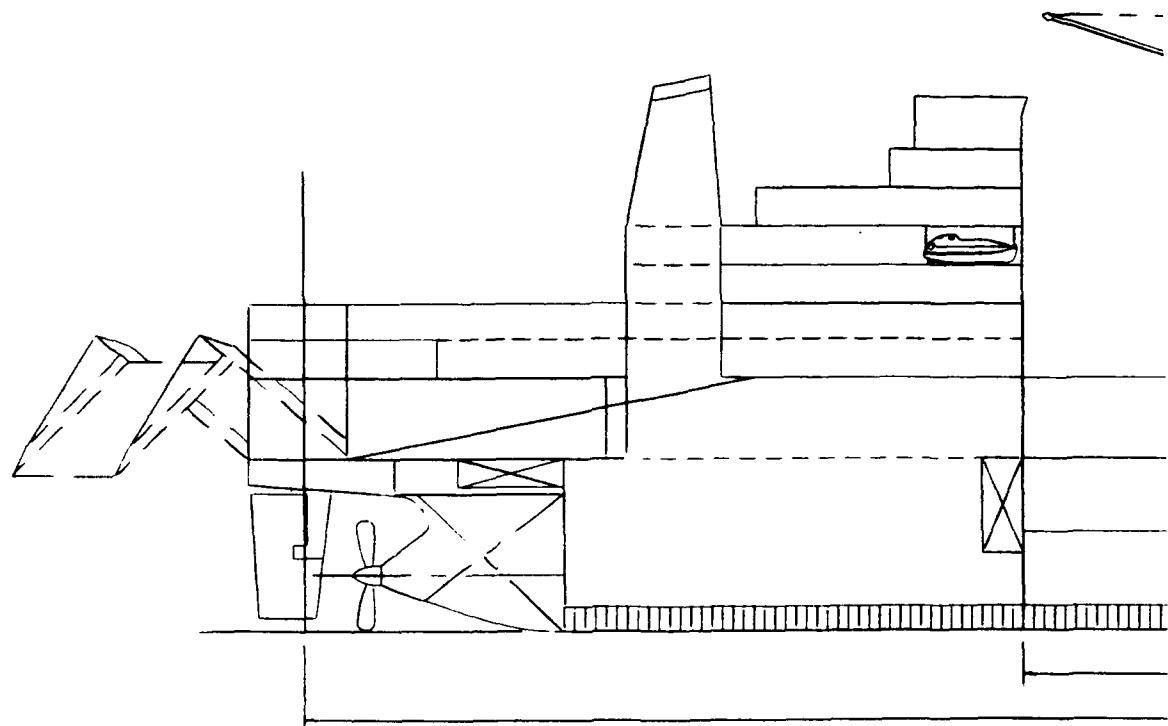


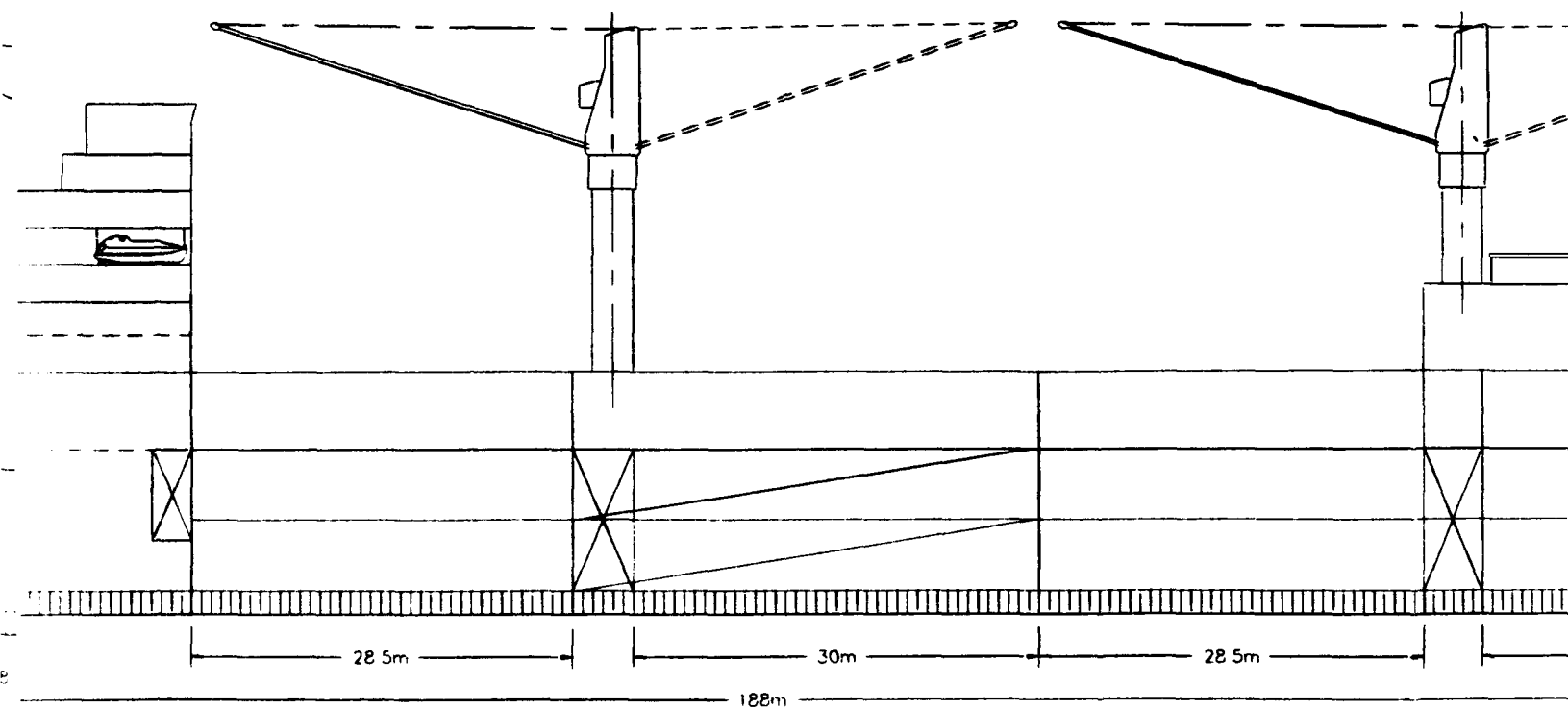
PORTABLE CONTAINER GUIDE SUPPORT FRAME

NOTE: GUIDE RAILS REMOVED FOR CLARITY

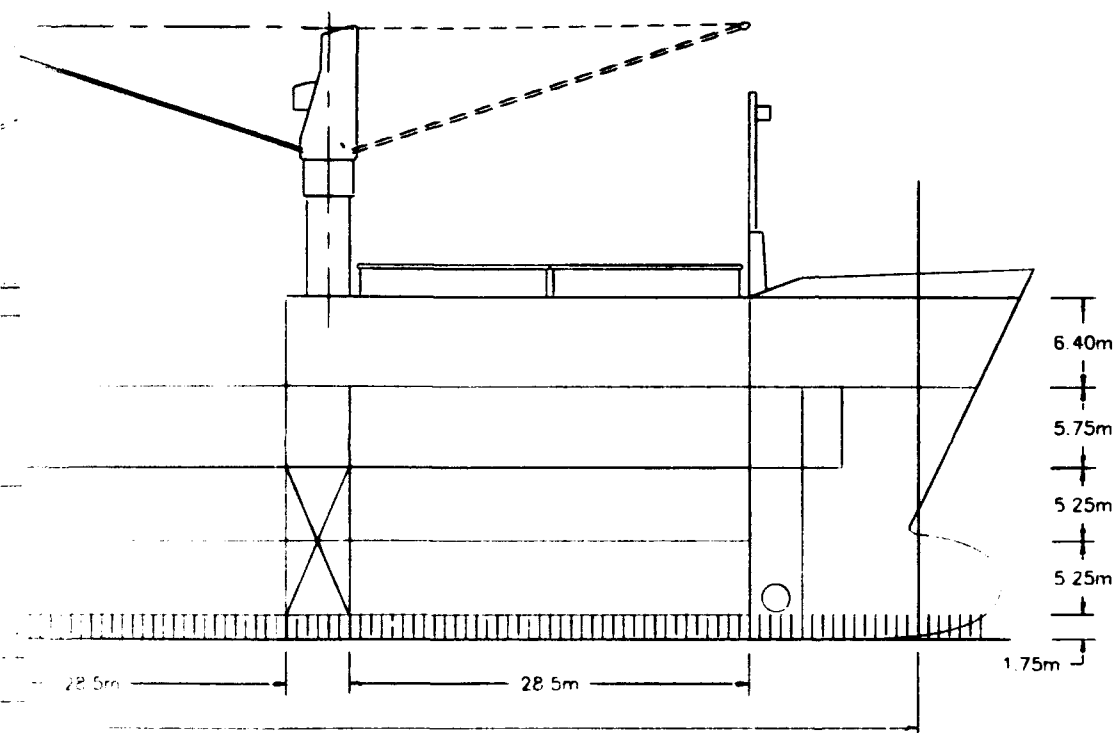
DRAWN BY:	APPROVED BY:
CTG	CF

SIZE	TSCM CASE NO	JFH DRAWING NO	REV
B	JFH	2852-00-04	—
SCALE	1/20	N/A	50 MSHEET 2 OF 2

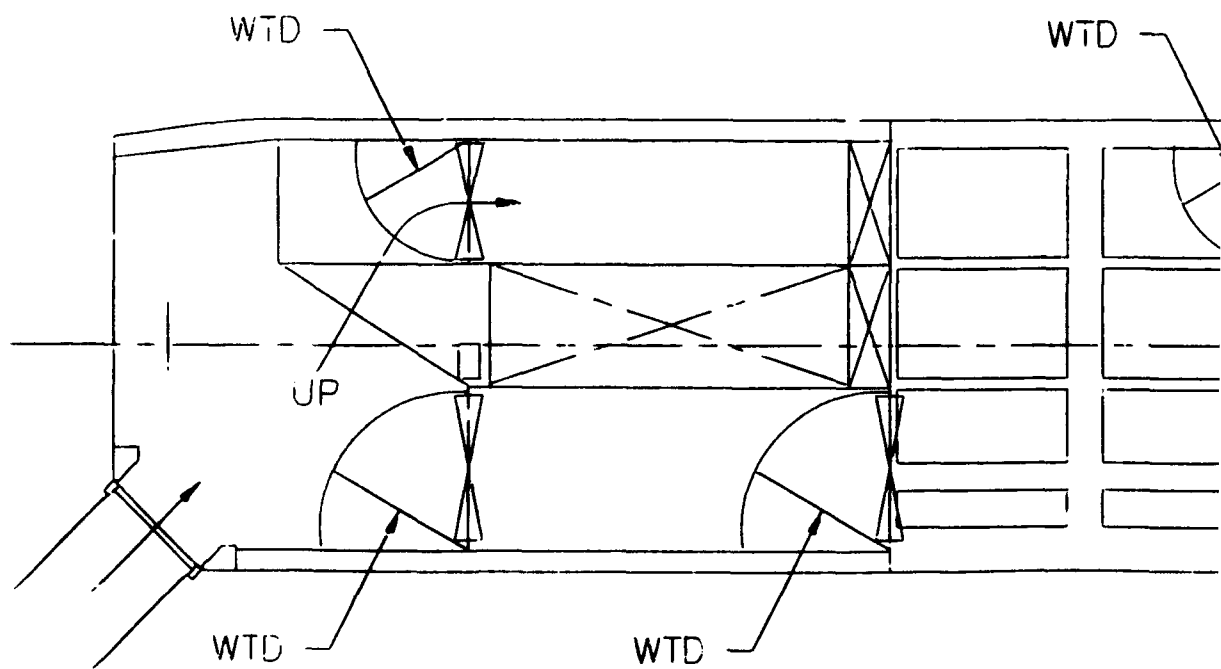
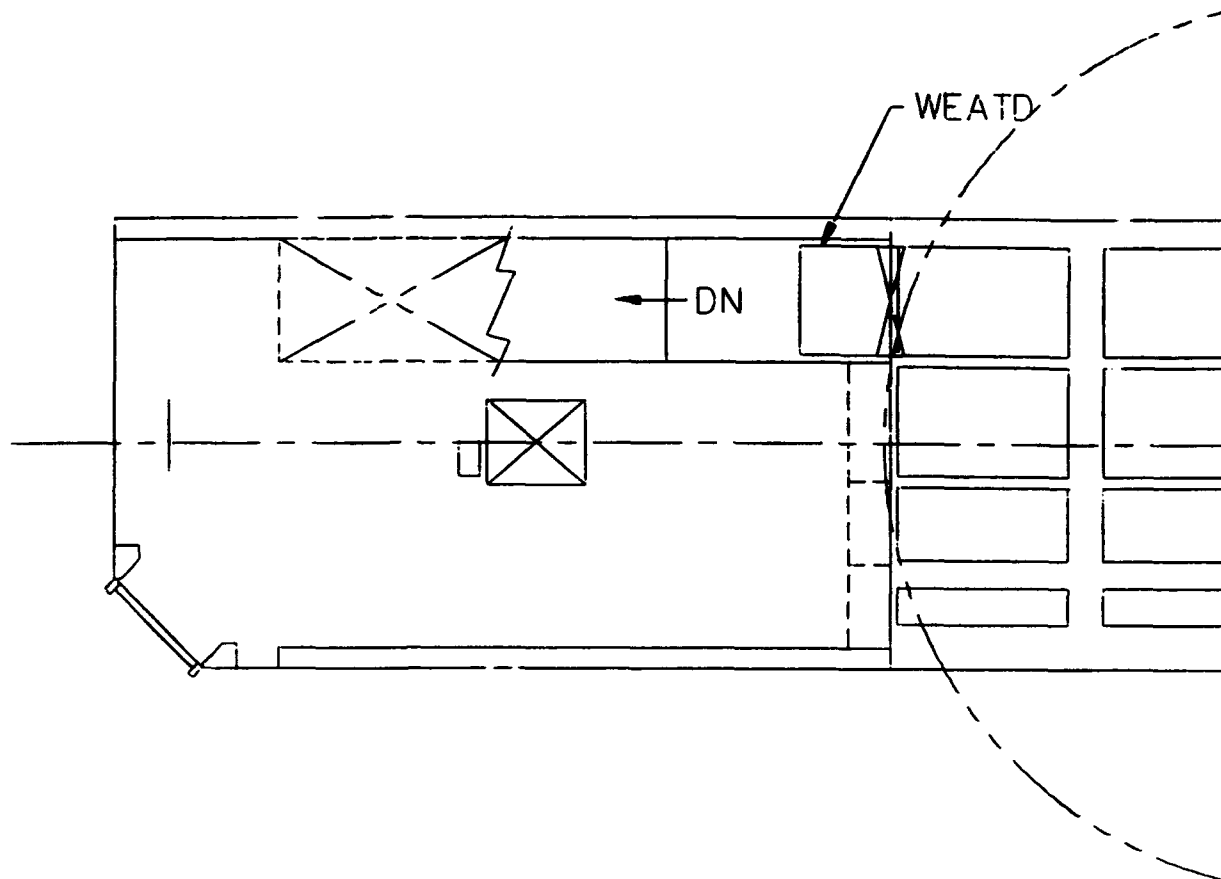


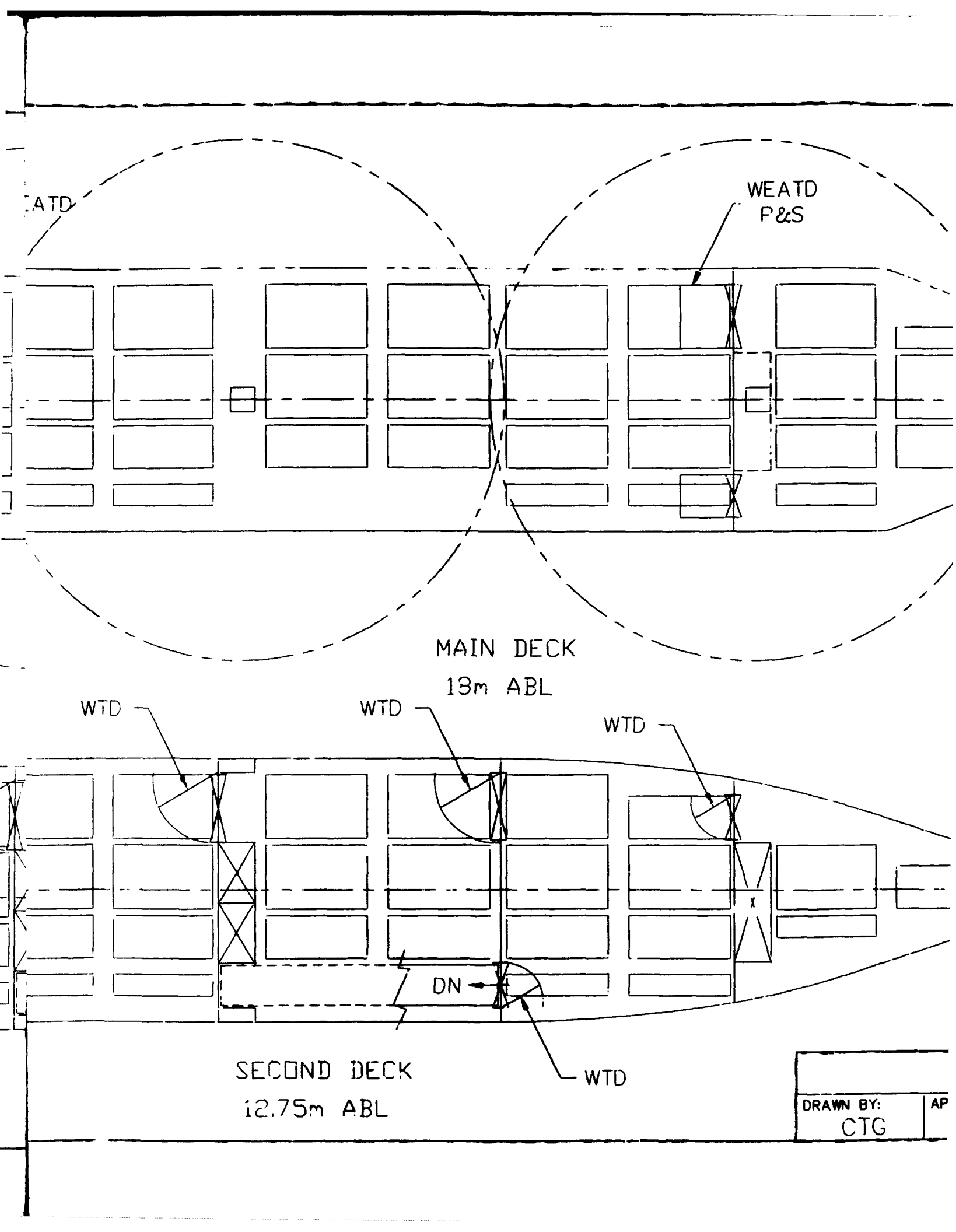


DRAWN BY	CTG
SUPVD BY	CF
APPROVED BY	CF



DRAWN BY CTG		CHECKED BY CTG		JH Inc. NAVAL ARCHITECTS-MARINE ENGINEERS CHERRY HILL, NJ PORTSMOUTH, VA CRYSTAL CITY, VA				
				ARRANGEMENTS RO/RO-CONTAINER CONVERTIBLE FULL SCANTLING SHIP				
SUPV'D BY CF		SIZE B		FSCM CAGE NO JJH		JJH DRAWING NO. 2852-00-01		REV —
APPROVED BY CF		SCALE 1/500		N/A		SQ M SHEET 1 OF 5		





ATD

WEATD
P&S

MAIN DECK
13m ABL

WTD

WTD

WTD

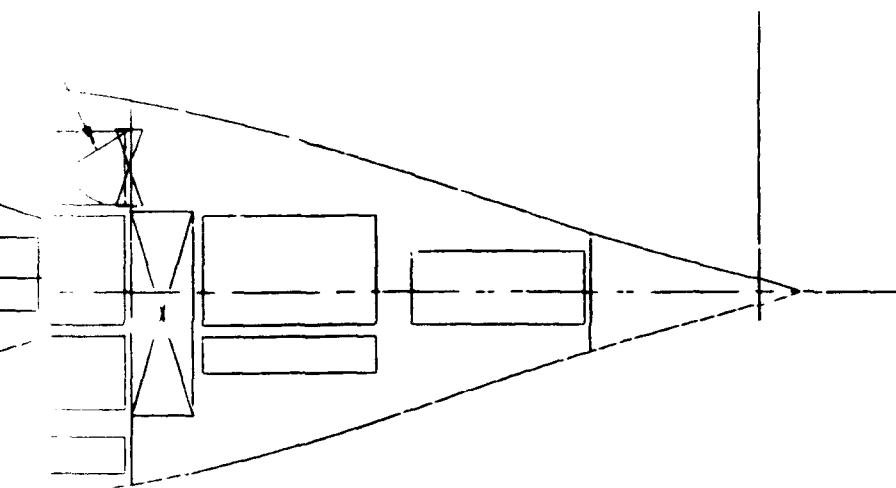
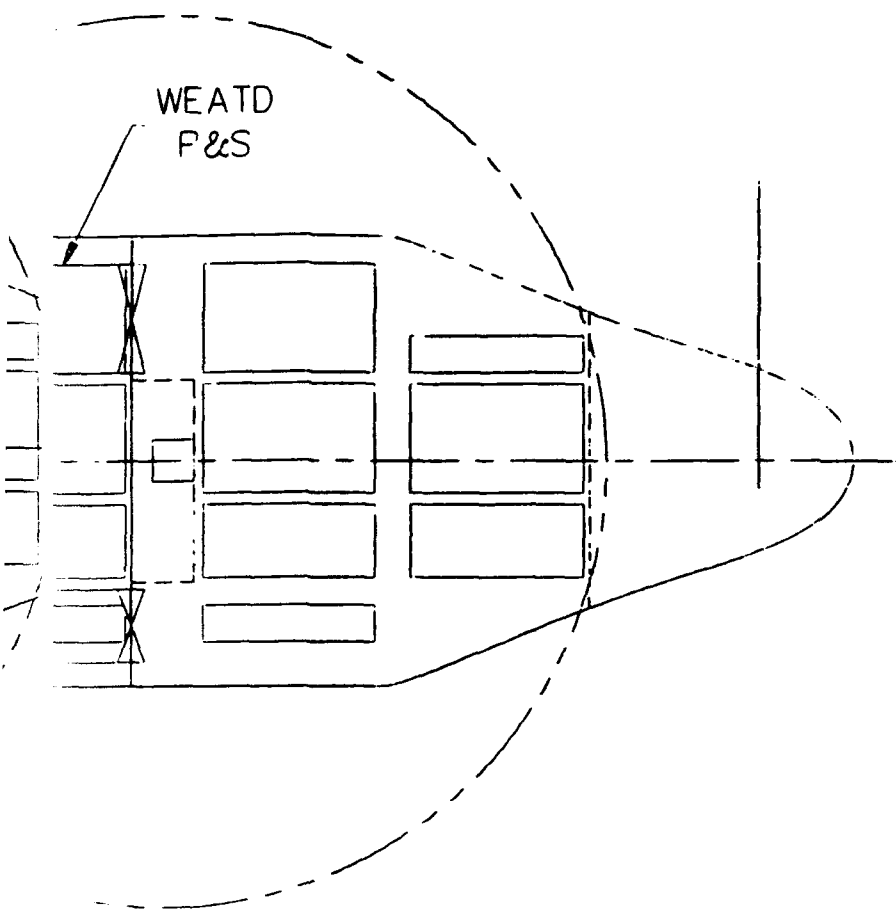
SECOND DECK
12.75m ABL

DN

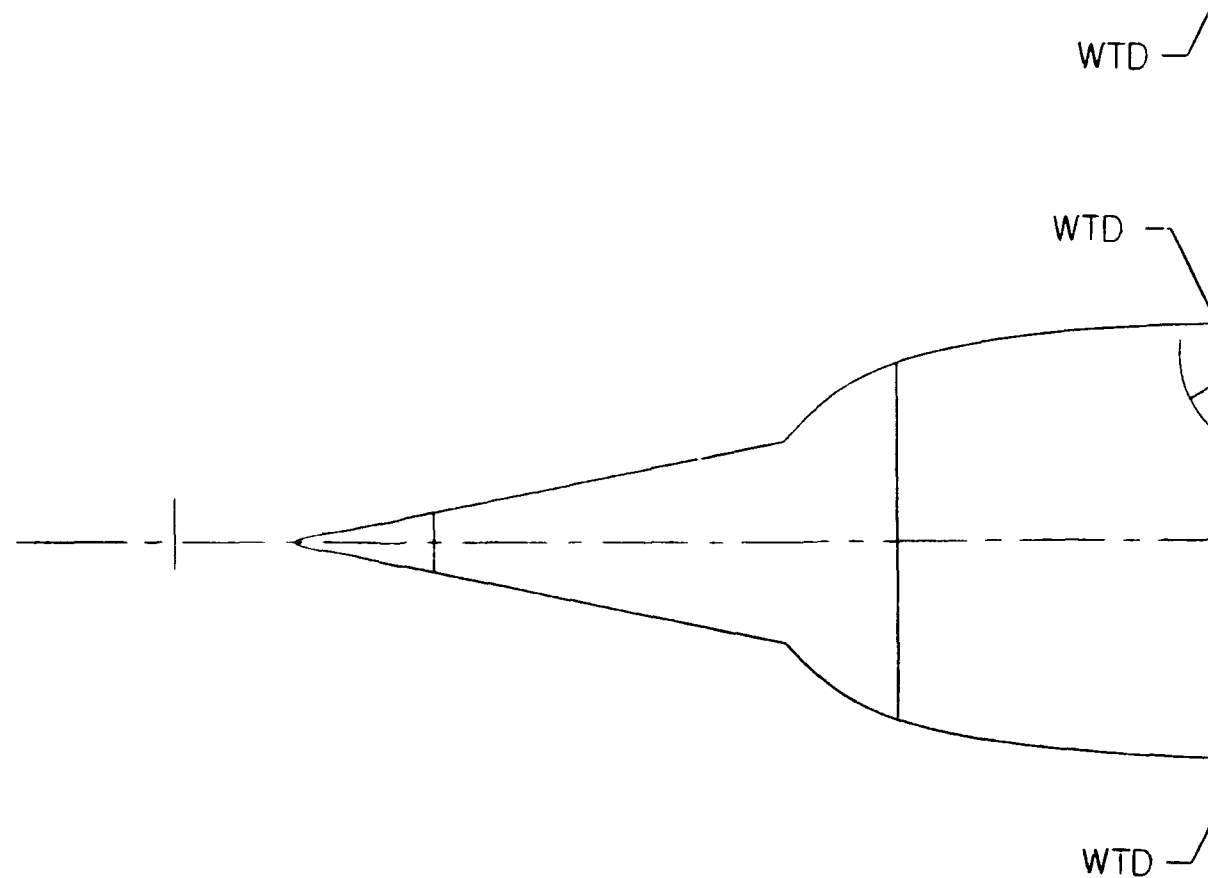
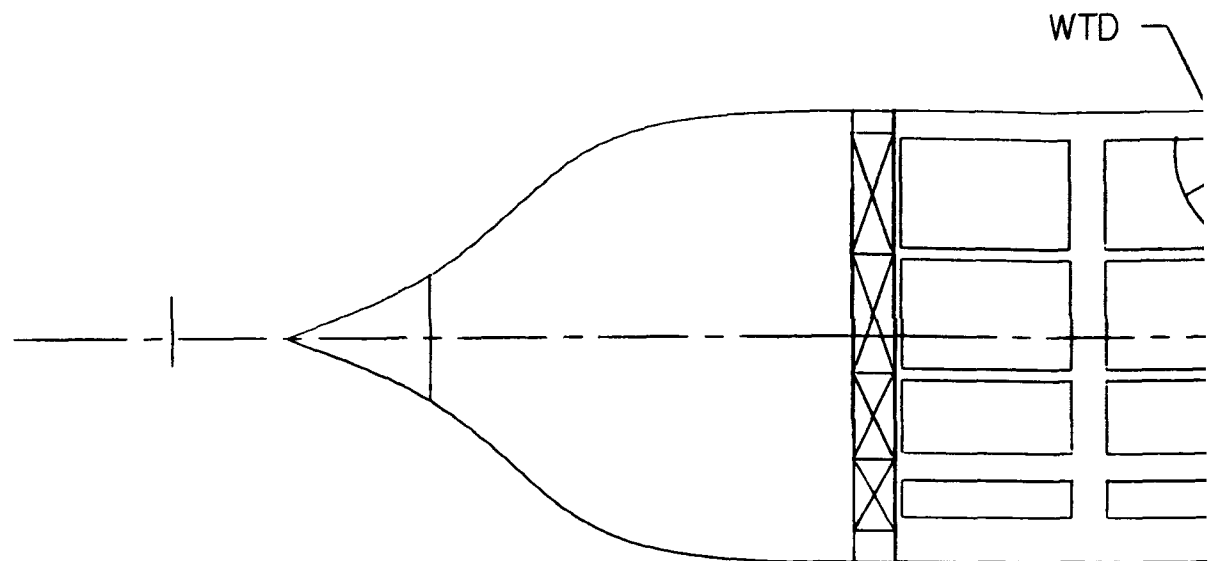
WTD

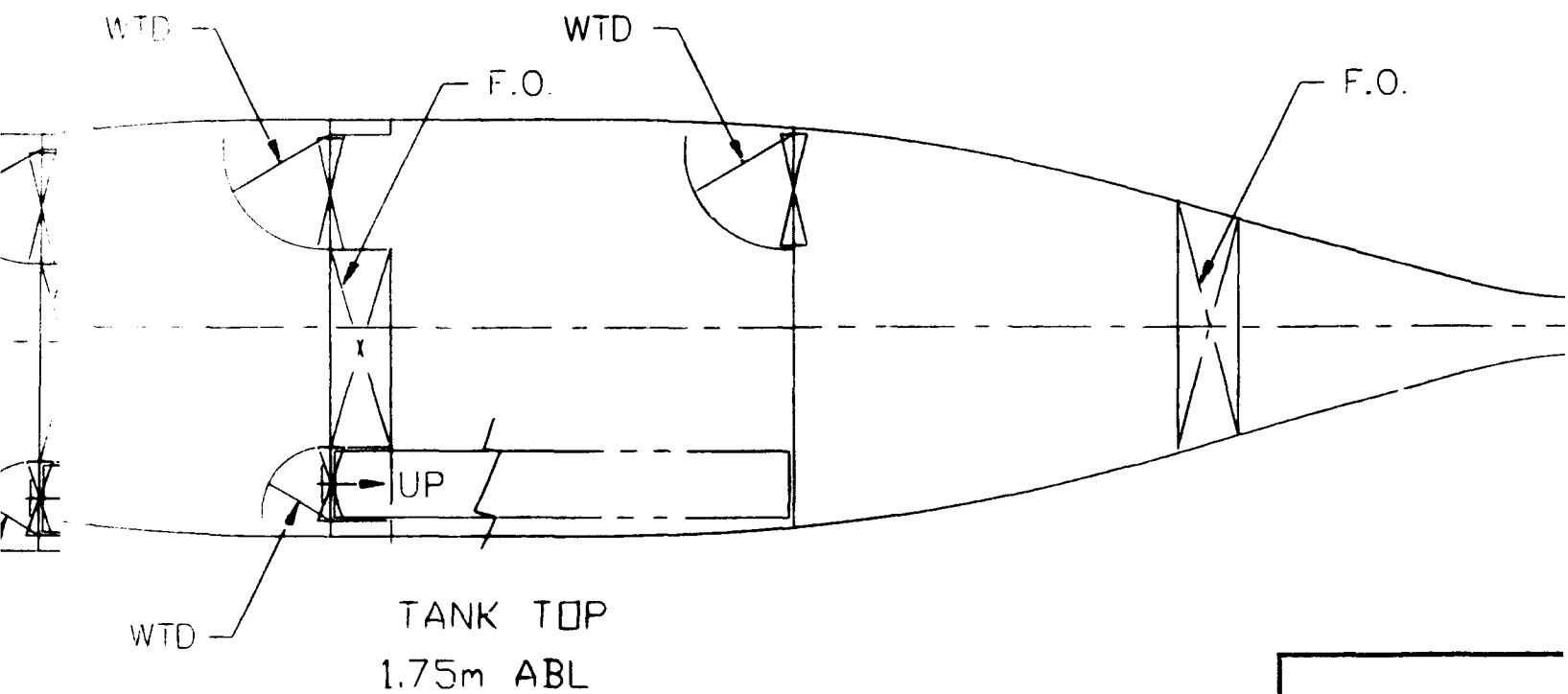
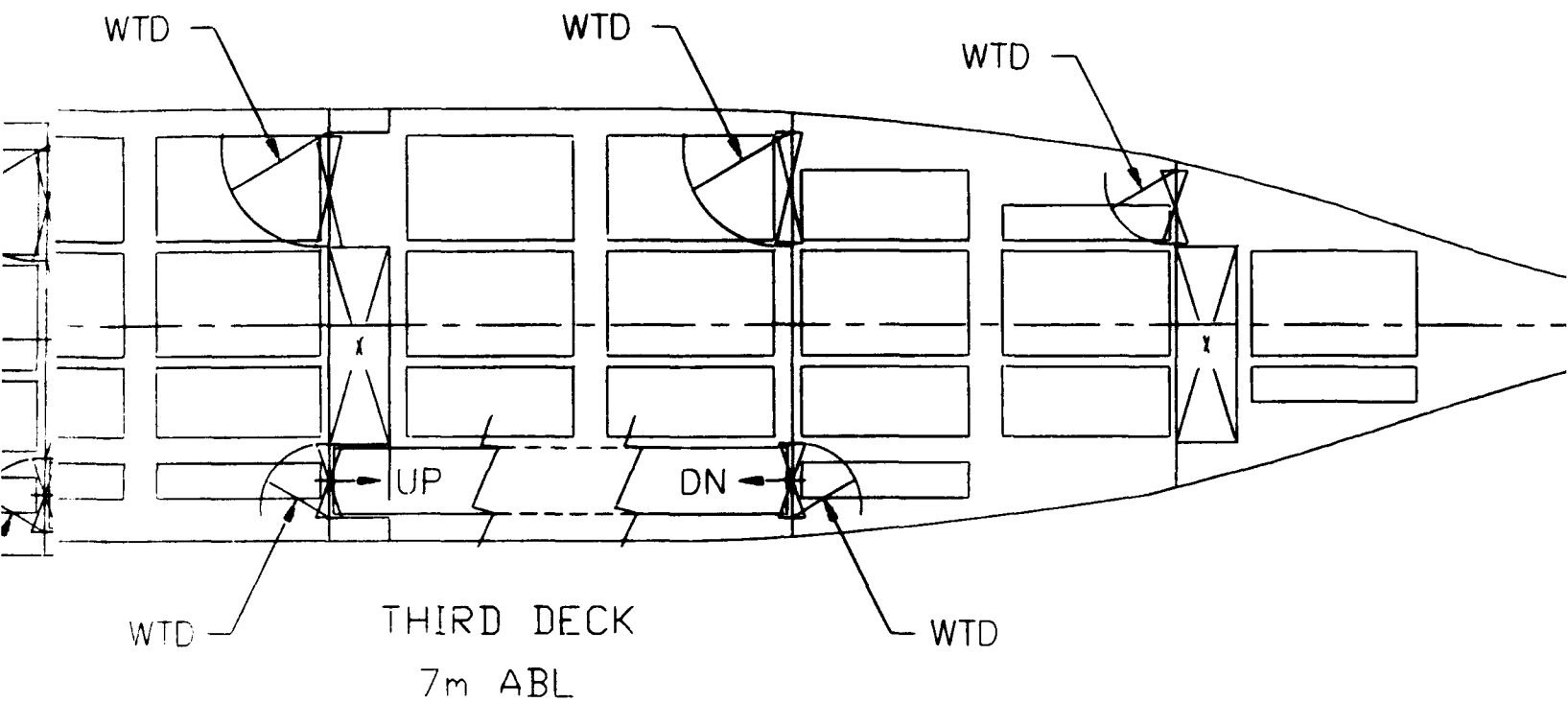
DRAWN BY:
CTG

AP

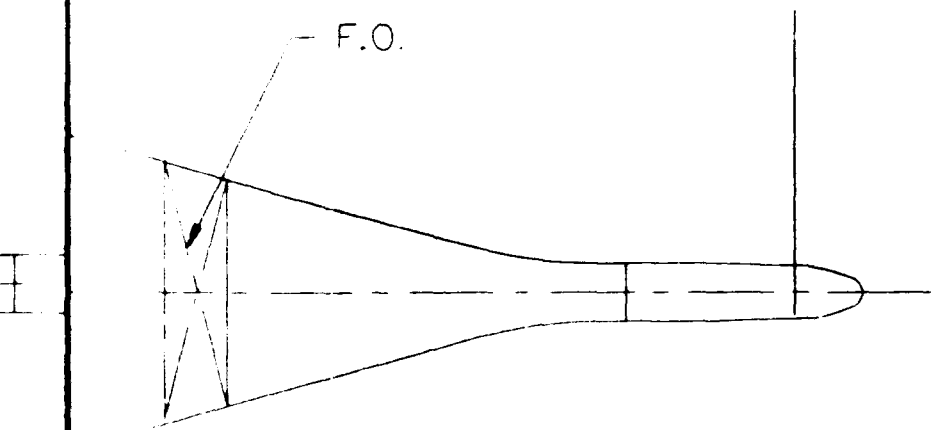
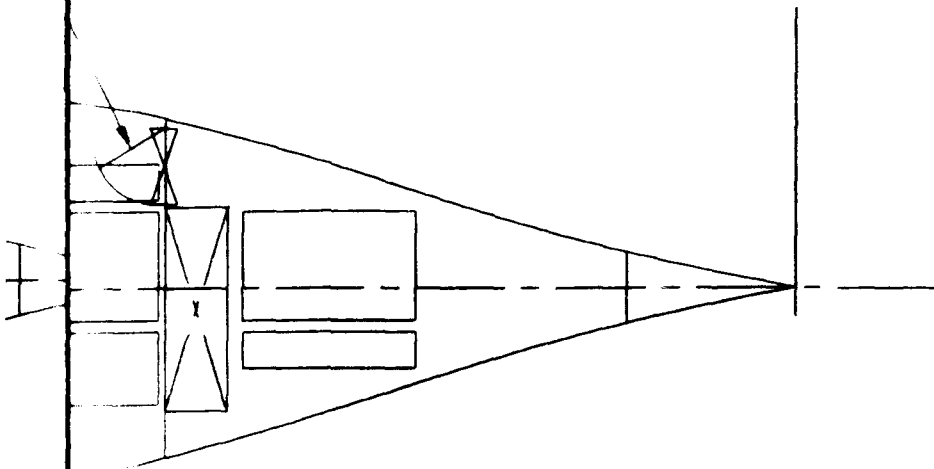


VED CF			SIZE	FSCM CAGE NO	JJH DRAWING NO	REV
	DRAWN BY: CTG	APPROVED BY: CF	B	JJH	2852-00-01	—
			SCALE 1/500	N/A	SQ M	SHEET 2 OF 5



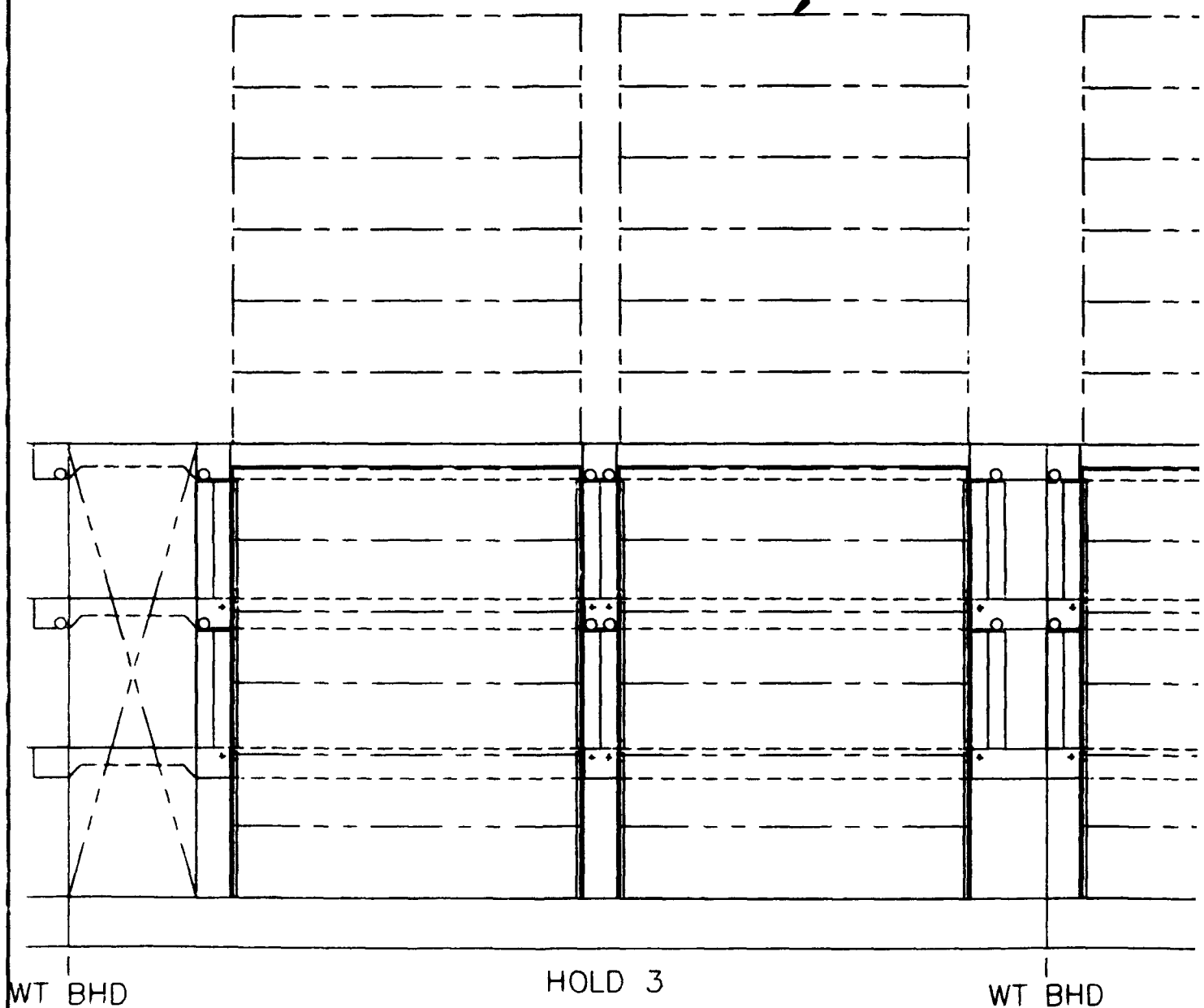


DRAWN BY:	APPR
CTG	



DRAWN BY: CTG	APPROVED BY: CF	SIZE B	FSCM CAGE NO JJH	JJH DRAWING NO 2852-00-01	REV —
		SCALE 1=500	N/A	SQ M	SHEET 3 OF 5

CONTAINERS (TYP)



WT BHD

HOLD 3

WT BHD

CARGO HOLDS RIGGED FOR (ELEVATION TO PORT OF

ERS (TYP)

HATCH SIDE GIRDERS
(WALKWAYS)

STRUCTURAL
BOX GIRDER
P&S

MN DK

2ND DK

3RD DK

T.T.

BHD

HOLD 2

WT BHD

B

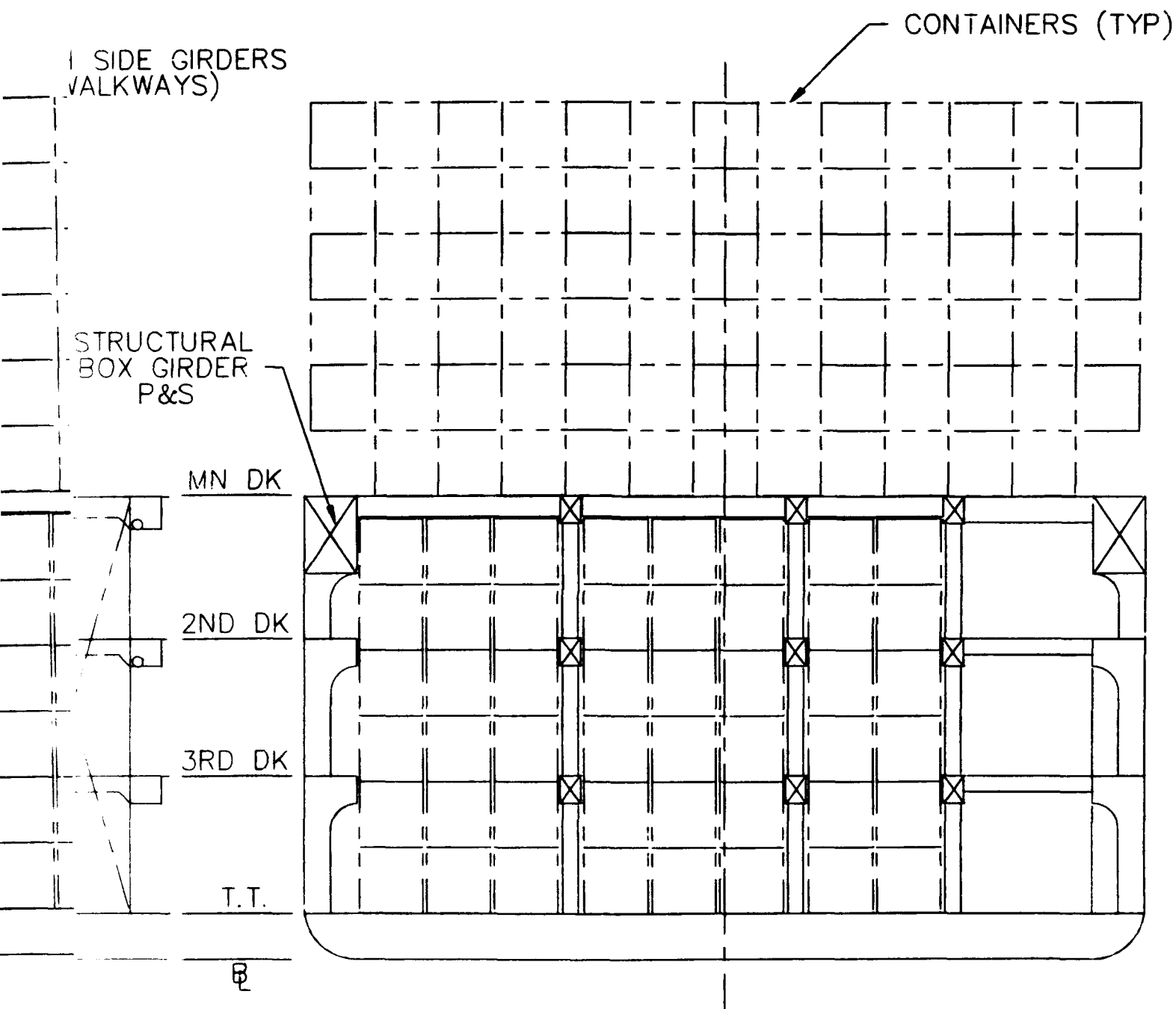
ONTO FOR CONTAINERS
(PORT OF RAMP)

C

DRAWN BY:

CTG

A



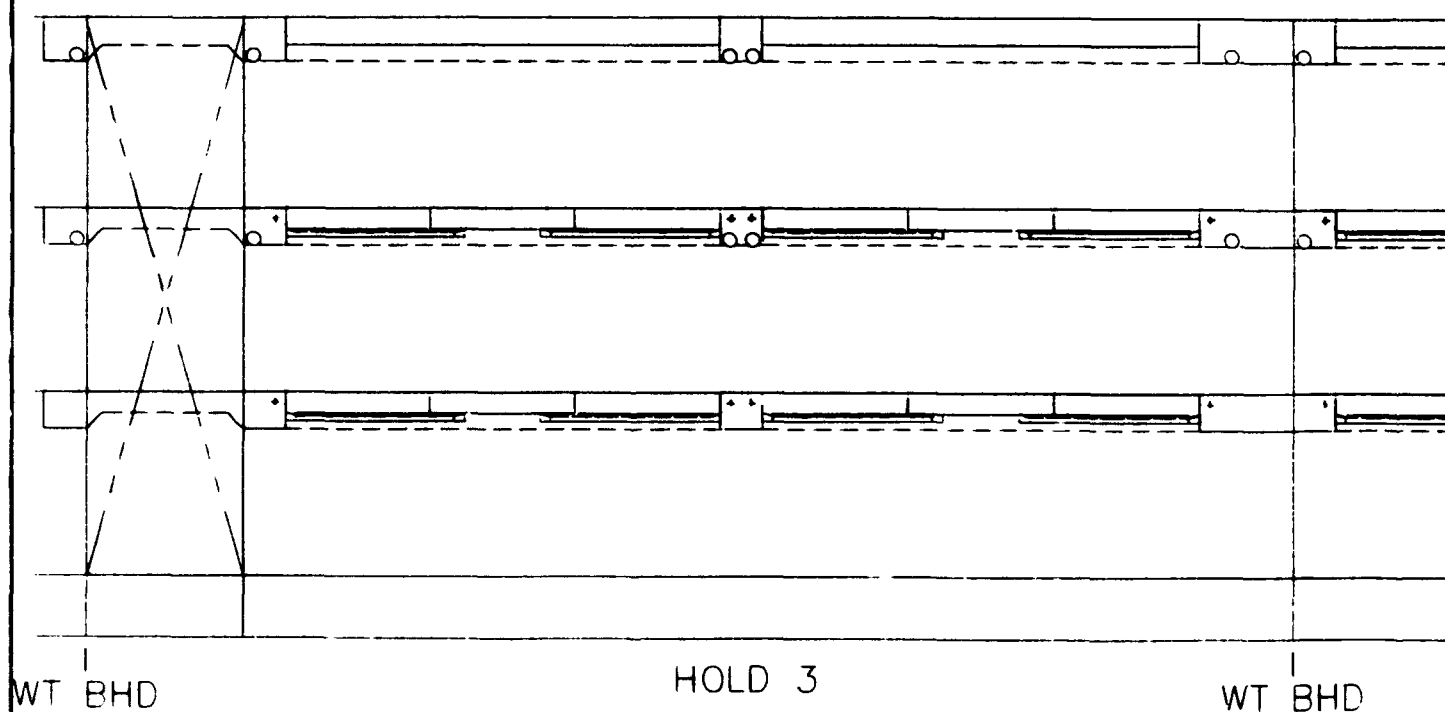
CROSS

CROSS SECTION OF CARGO HOLD (IN WAY OF RAMPS)

APPROVED BY:
CF

DRAWN BY: CTG		APPROVED BY: CF	
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SIZE B	FSCM CAGE NO JJH	JJH DRAWING NO. 2852-00-01	REV —
SCALE 1=200		N/A	SQ M SHEET 4 OF 5



CARGO HOLDS RIGGED FOR
(ELEVATION TO PORT C)

HATCH SIDE GIRDERS
(WALKWAYS)

STRUCTURAL
BOX GIRDER
P&S

MN DK

2ND DK

3RD DK

T.T.

WT BHD

HOLD 2

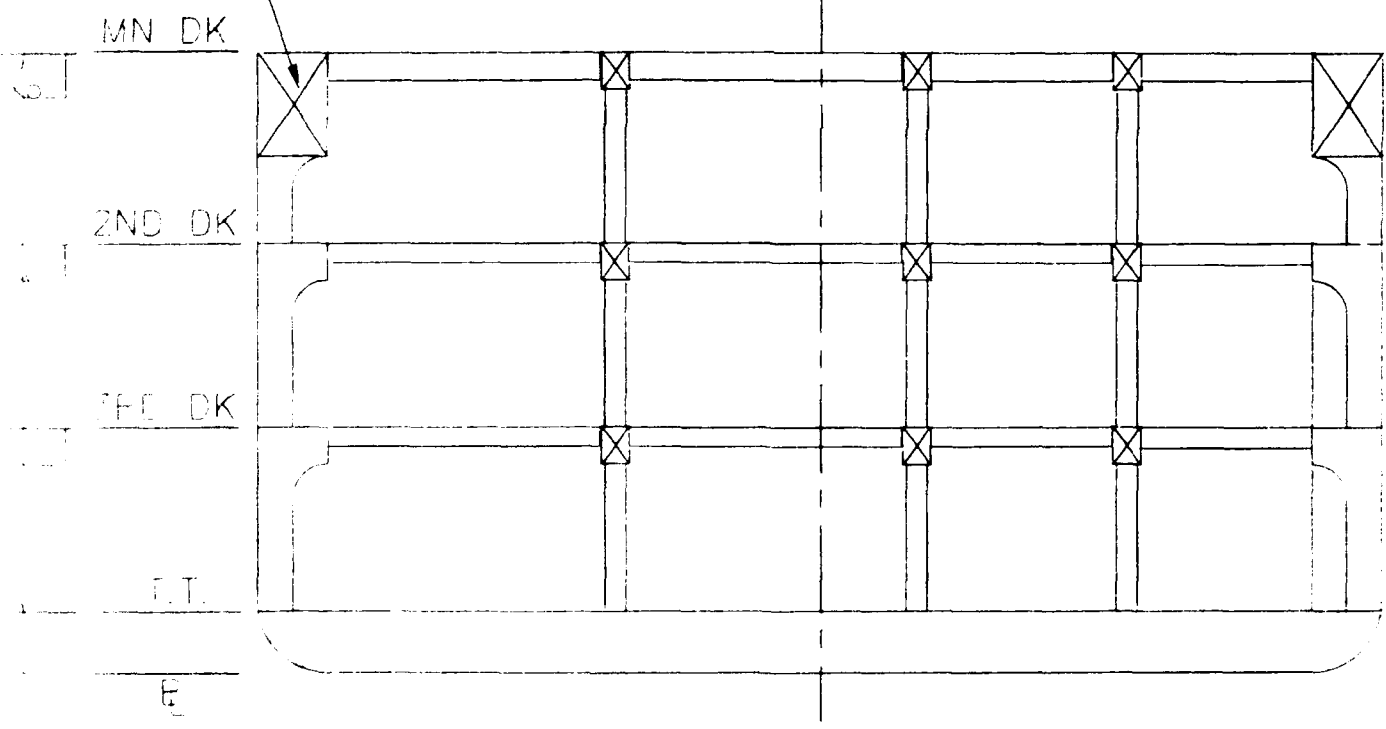
WT RHD

BL

R RIGGED FOR RO/RO
(RAID PORT OF RAMP)

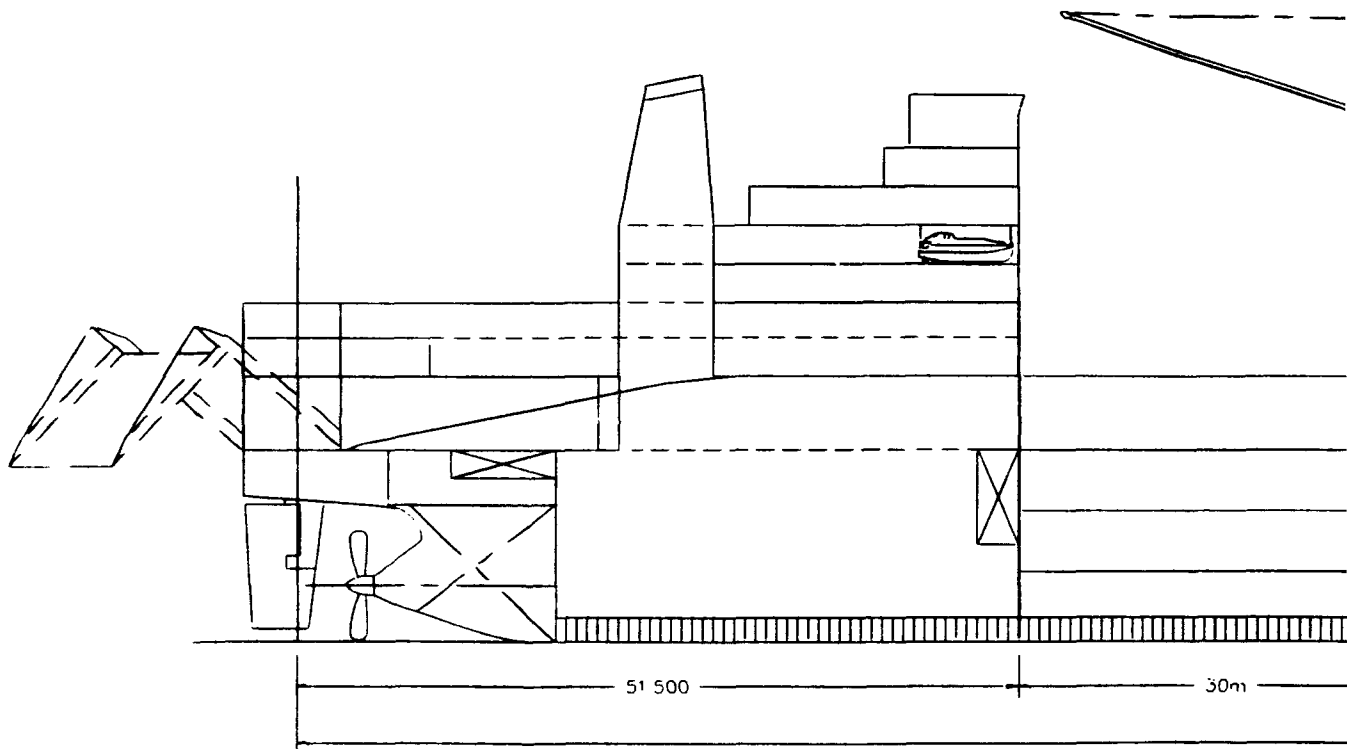
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CTG

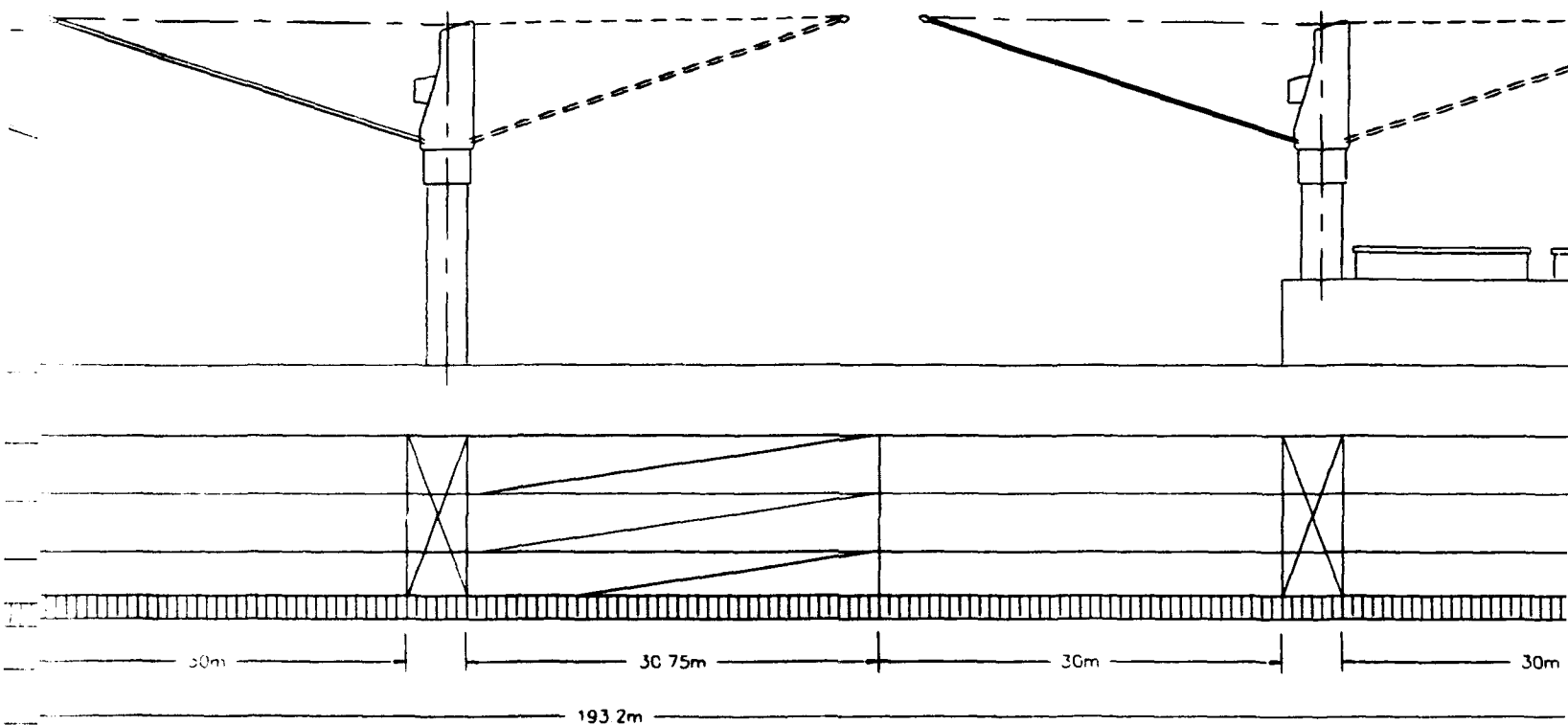
STRUCTURAL
X GIRDER
P&S



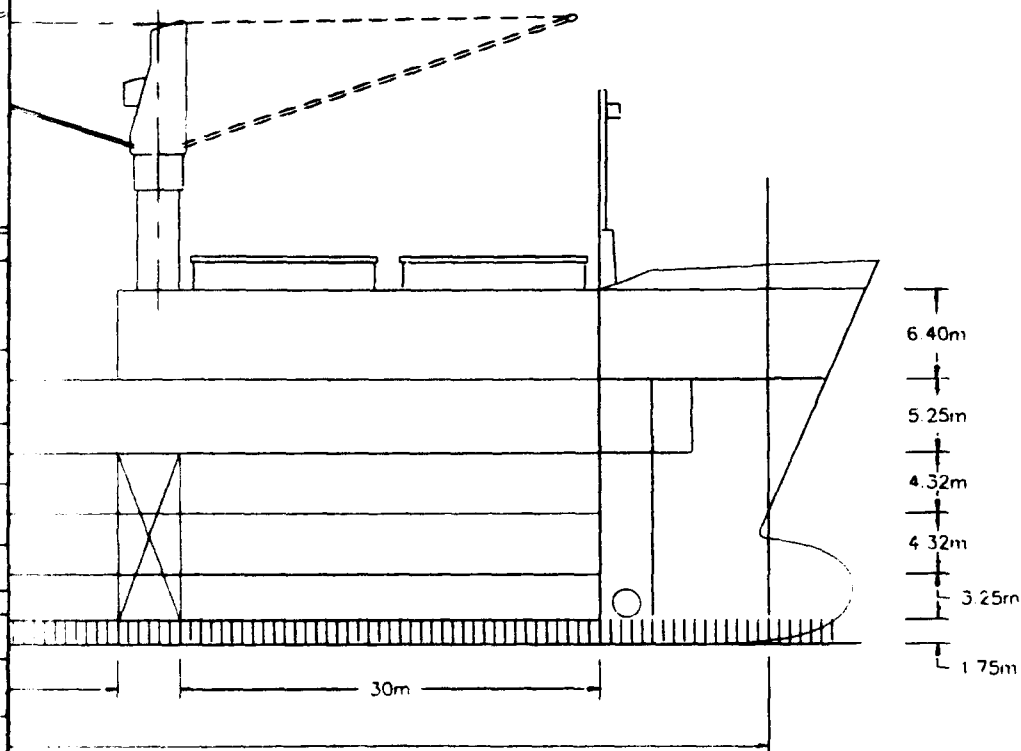
CROSS SECTION OF CARGO HOLD
(IN WAY OF RAMPS)


		SIZE	FSCM CAGE NO	JJH DRAWING NO.	REV
DRAWN BY	APPROVED BY:	B	JJH	2852-00-01	—
CTG	CF	SCALE 1=200	N/A	SQ M	SHEET 5 OF 5

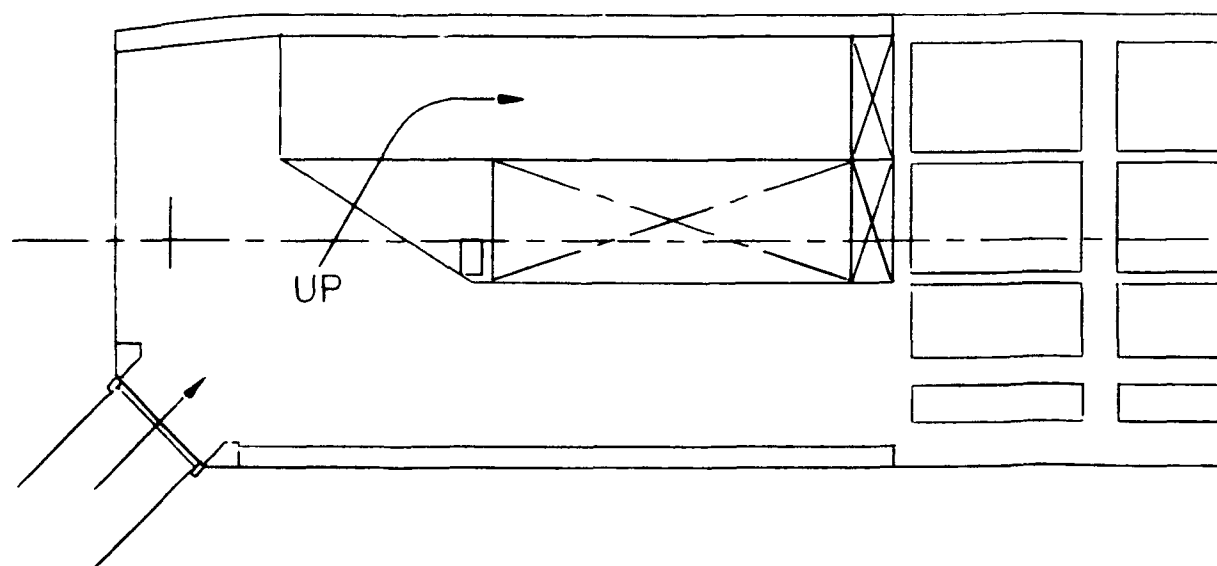
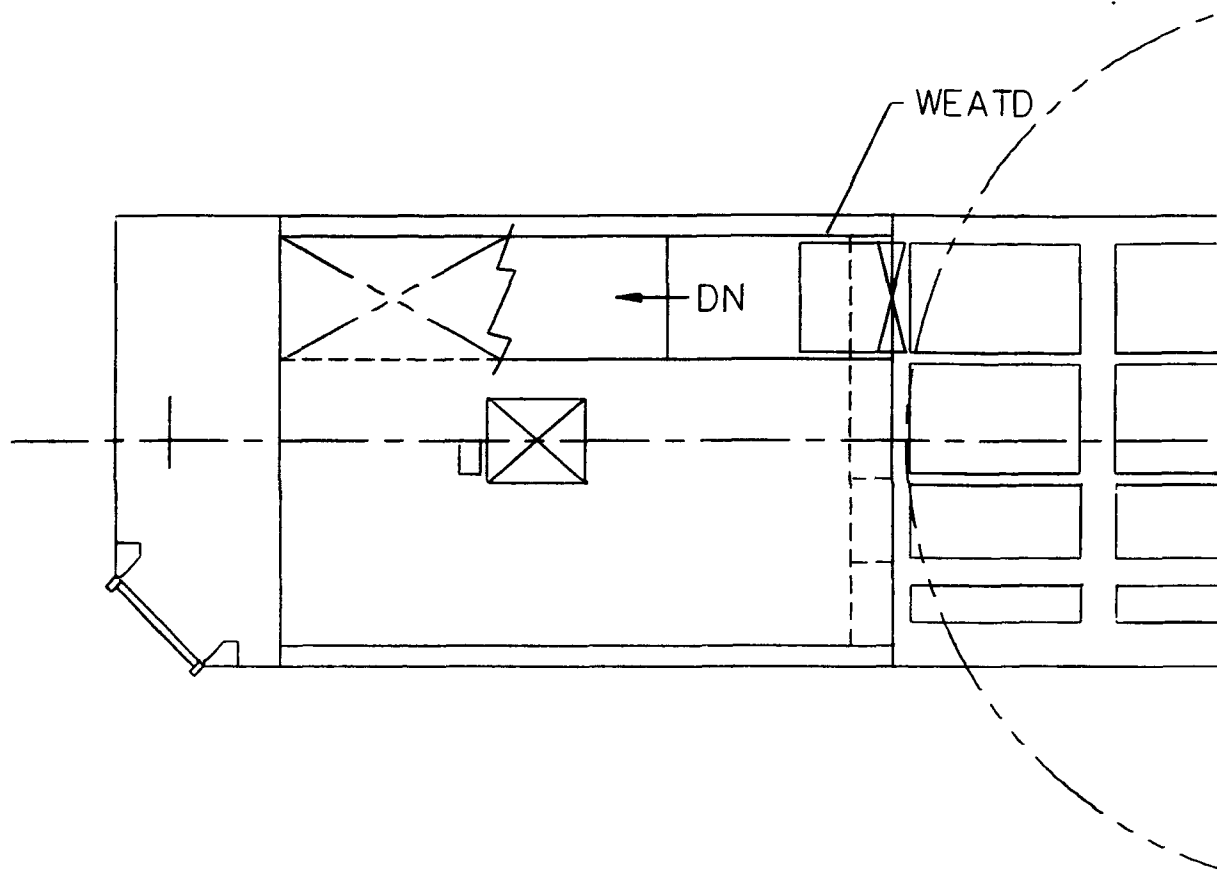


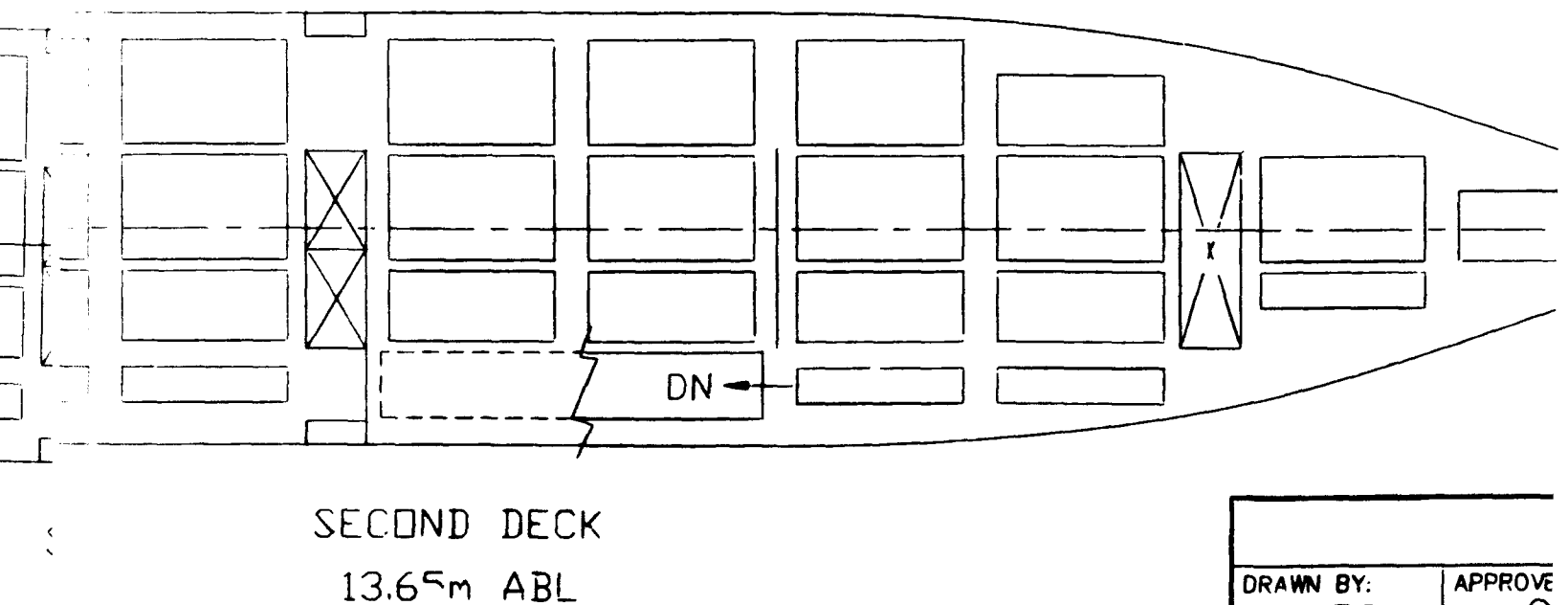
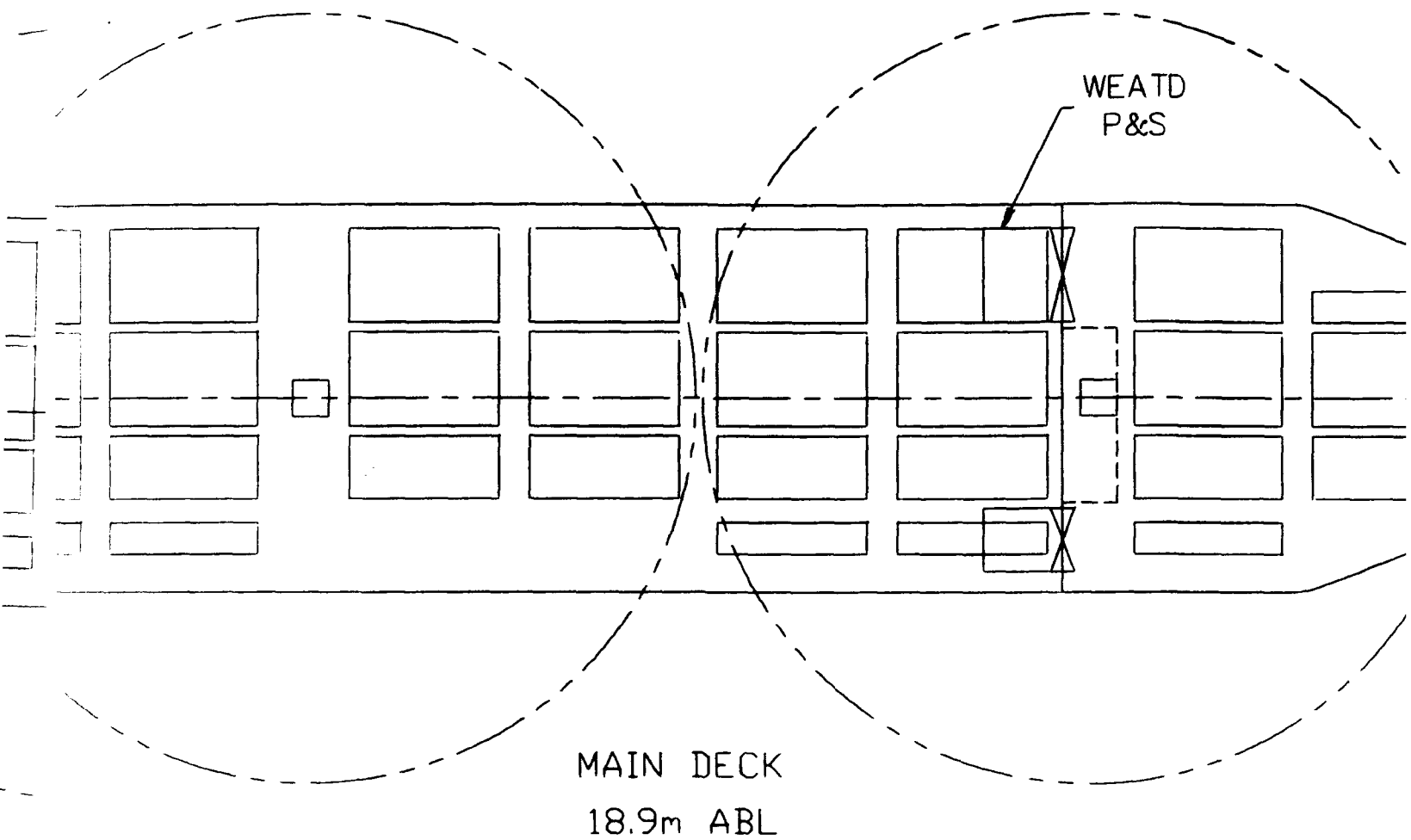


DRAWN BY	CF
CTG	
SUPVD BY	CF
APPROVED BY	CF

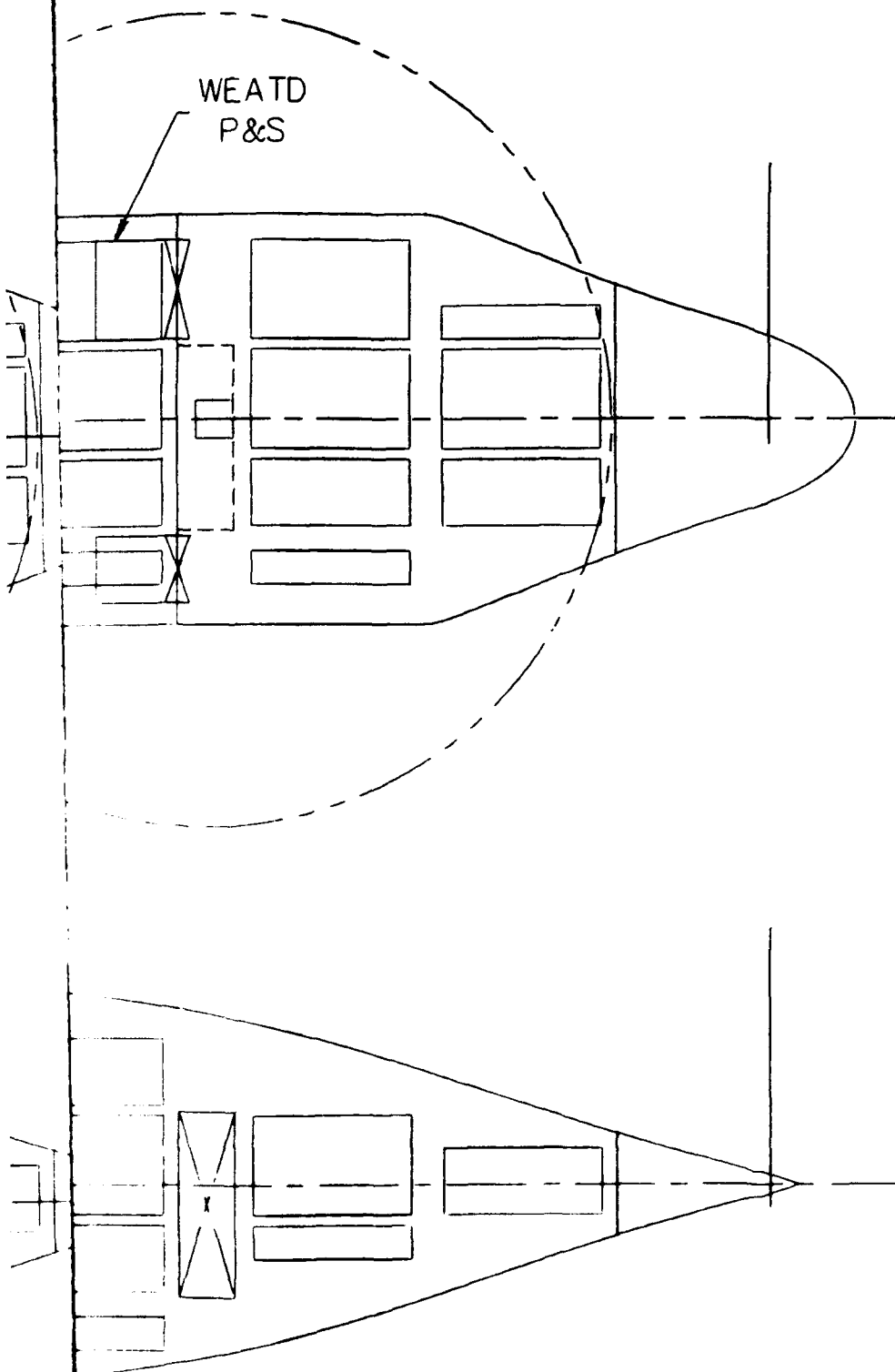


DRAWN BY CTG		CHECKED BY CTG		 JH Inc. NAVAL ARCHITECTS-MARINE ENGINEERS <small>CHERRY HILL, NJ PORTSMOUTH, VA CRYSTAL CITY, VA</small>		
				ARRANGEMENTS RO/RO-CONTAINER CONVERTIBLE SHELTER DECK SHIP		
SUPVD BY CF		SIZE B	FSCM CAGE NO JJH	JH DRAWING NO. 2852-00-02	REV —	
APPROVED BY CF		SCALE 1/500		N/A	SO M SHEET 1 OF 4	

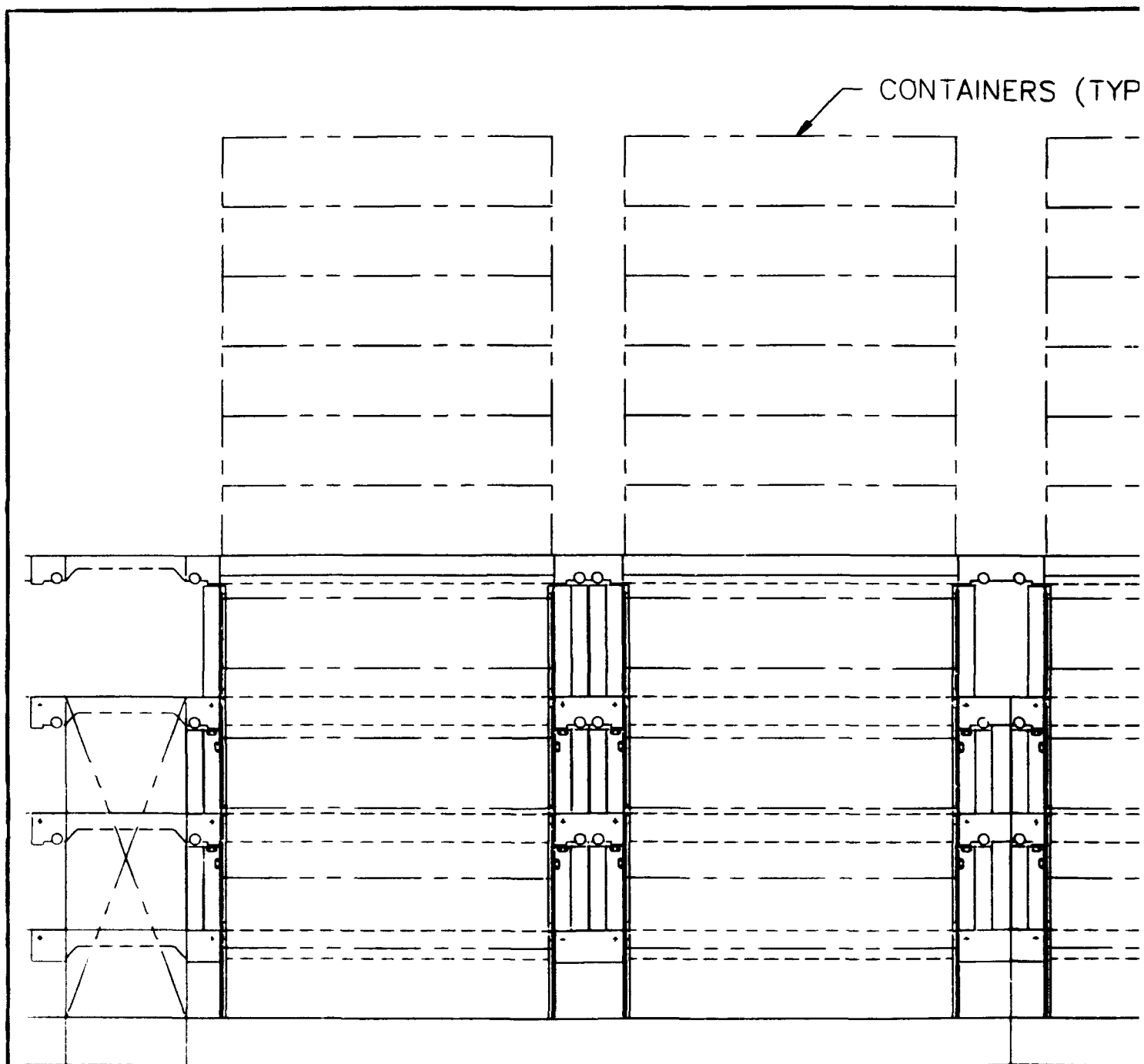




DRAWN BY: CTG	APPROVE C
------------------	--------------



BY:			SIZE	FSCM CAGE NO	JJH DRAWING NO	REV
	DRAWN BY:	APPROVED BY:	B	JJH	2852-00-02	-
	CTG	CF	SCALE 1/500		N/A SQ M	SHEET 2 OF 4



WT BHD

HOLD 3

WT BHD

CARGO HOLDS RIGGED FOR (C)
(ELEVATION TO PORT OF)

CONTAINERS (TYP)

HATCH SIDE GIRDERS
(WALKWAYS)

STRUCTURAL
BOX GIRDER
P&S

MN DK

2ND DK

3RD DK

4TH DK

T.T.

WT BHD

HOLD 2

WT BHD

⊕

CONTAINERS (TYP)
(PORT OF RAMP)

DRAWN BY:
CTG

H SIDE GIRDERS
(WALKWAYS)

CONTAINERS (TYP)

STRUCTURAL
BOX GIRDER
P&S

MN DK

2ND DK

3RD DK

4TH DK

T.T.

B

PHD

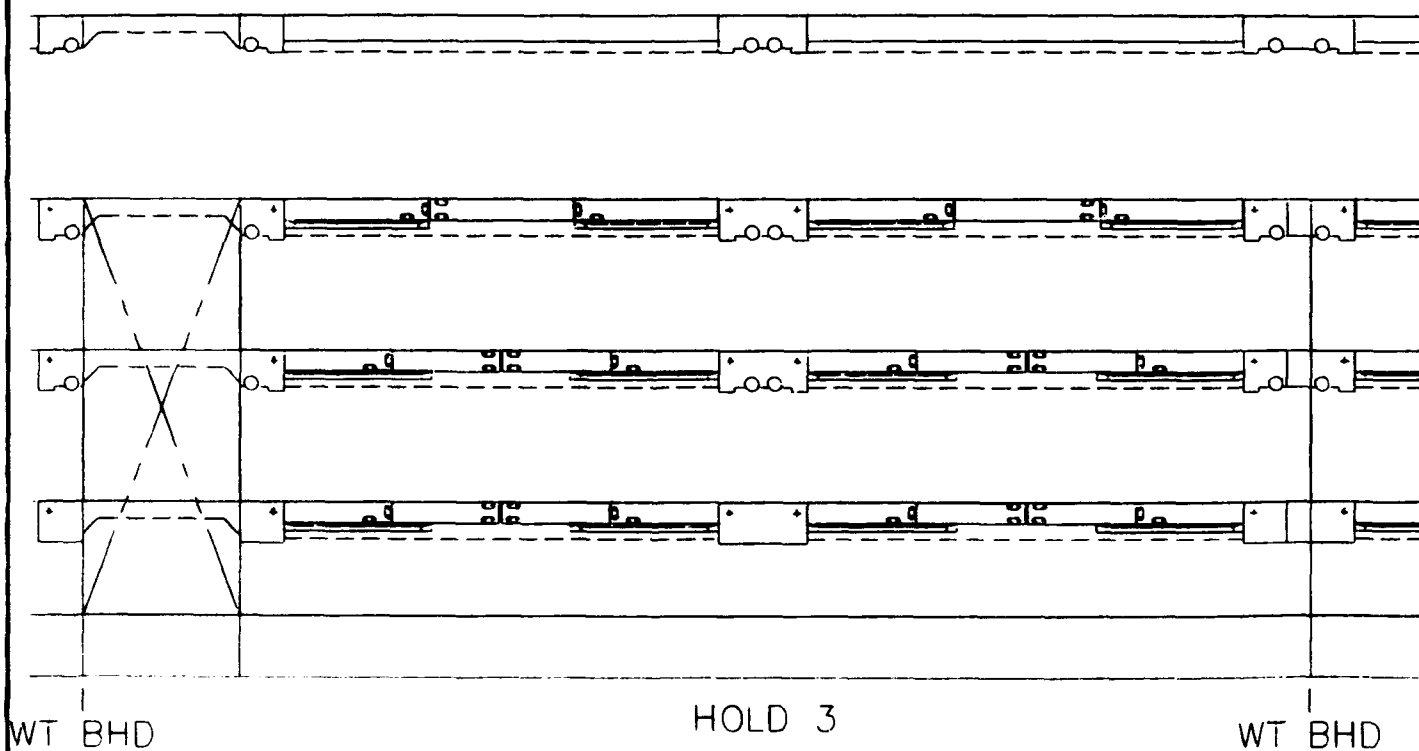
CROSS

CROSS SECTION OF CARGO HOLD (IN WAY OF RAMPS)

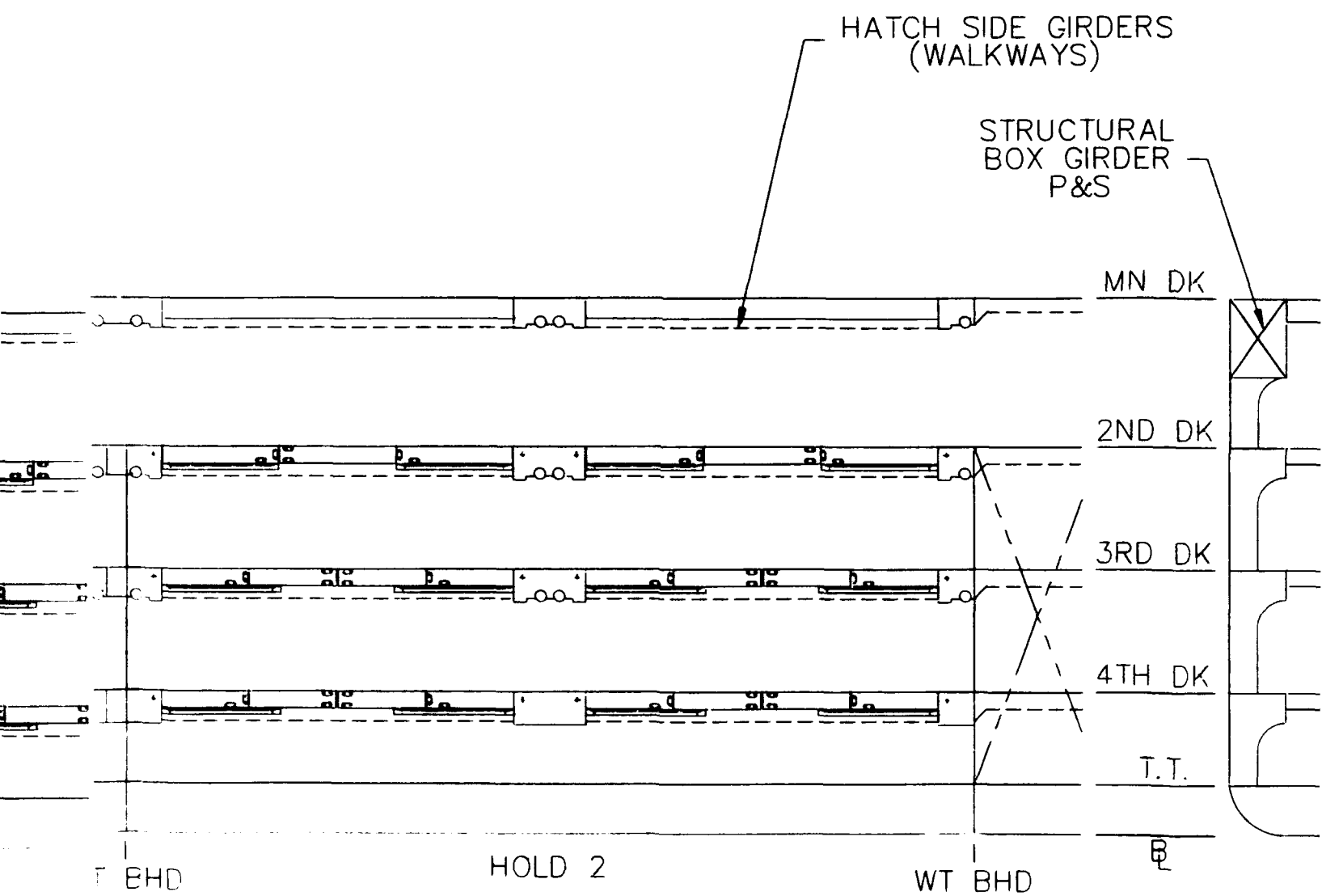
APPROVE
C

DRAWN BY. CTG		APPROVED BY. CF	
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SIZE B	FSCM CAGE NO JJH	JJH DRAWING NO 2852-00-02	REV —
SCALE 1=200		N/A	SQ M SHEET 3 OF 4



CARGO HOLD RIGGED F
(ELEVATION TO PORT

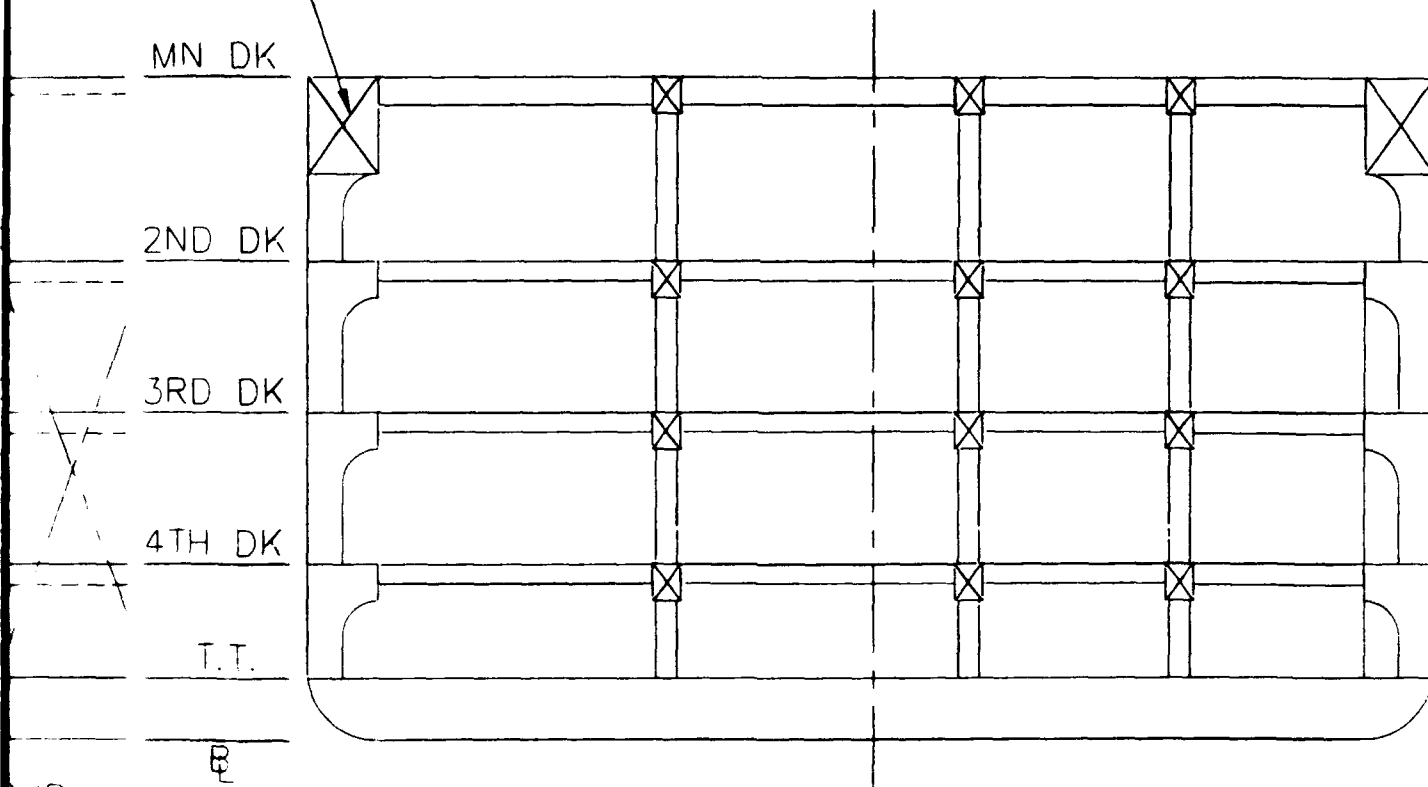


FOR RO/RO
 (PORT OF RAMP)

DRAWN BY:
 CTG

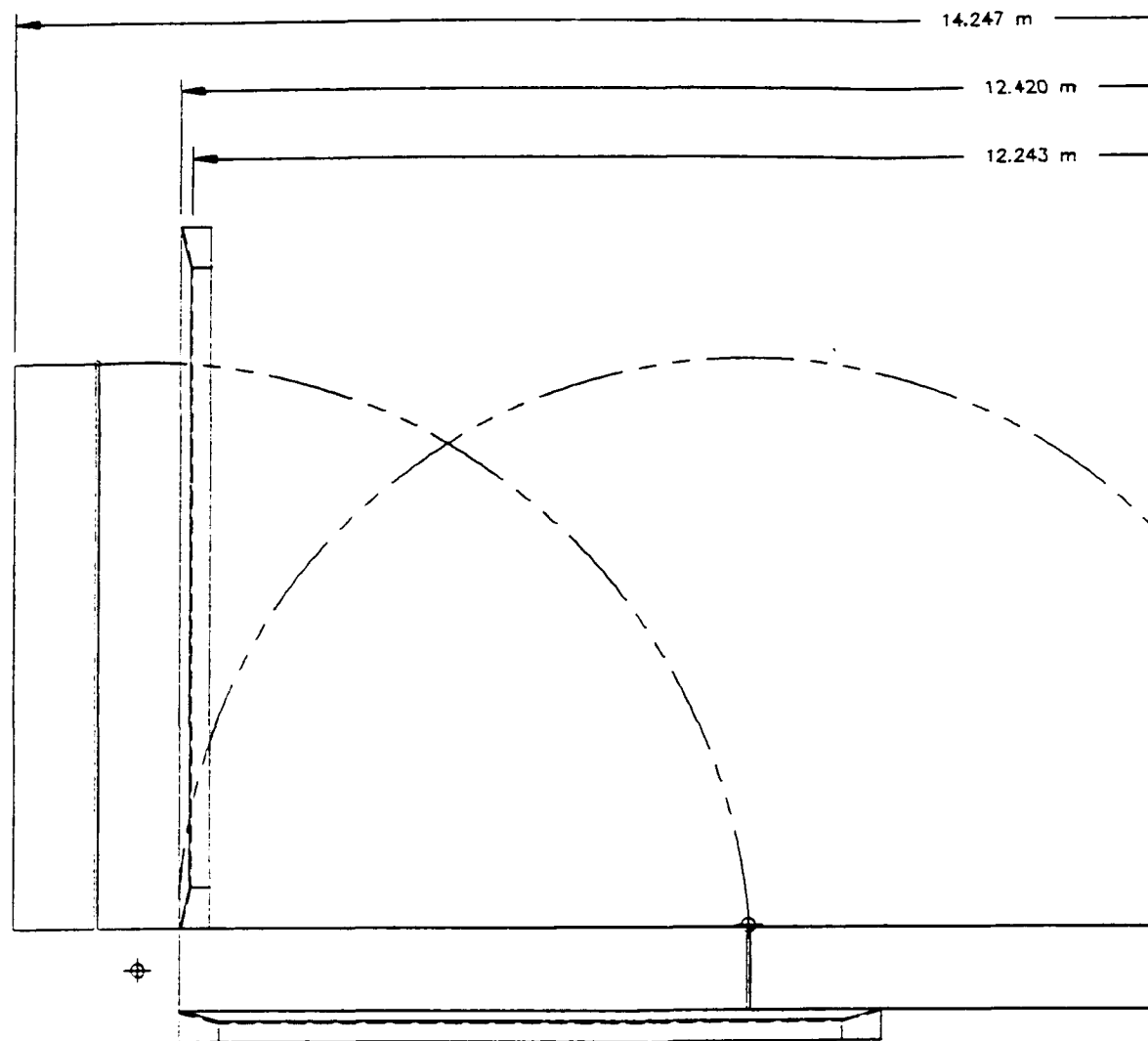
DE GIRDERS
(WAYS)

STRUCTURAL
BOX GIRDER
P&S



CROSS SECTION OF CARGO HOLD
(IN WAY OF RAMPS)

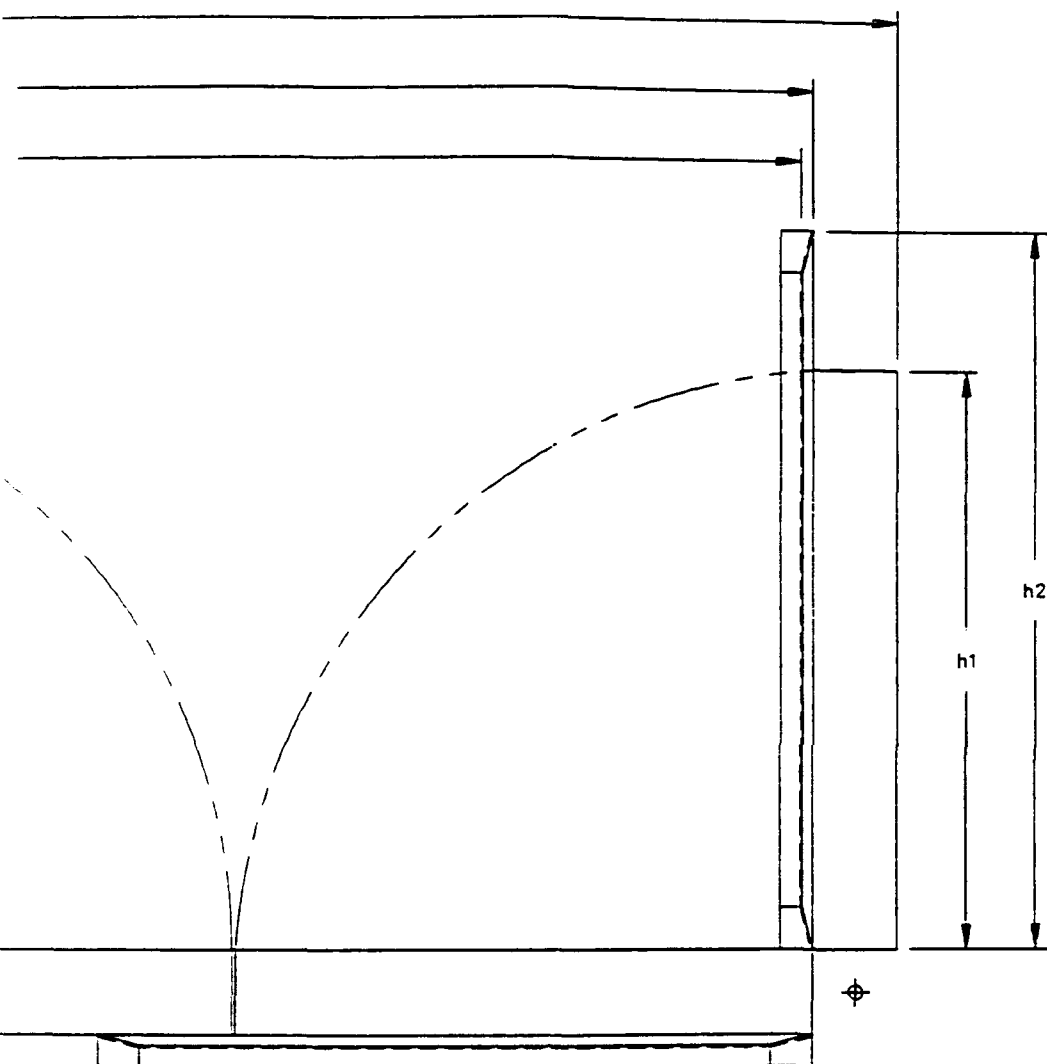
		SIZE	FSCM CAGE NO	JJH DRAWING NO.	RE
DRAWN BY:	APPROVED BY:	B	JJH	2852-00-02	-
CTG	CF	SCALE 1=200		N/A SQ M	SHEET 4 OF 4



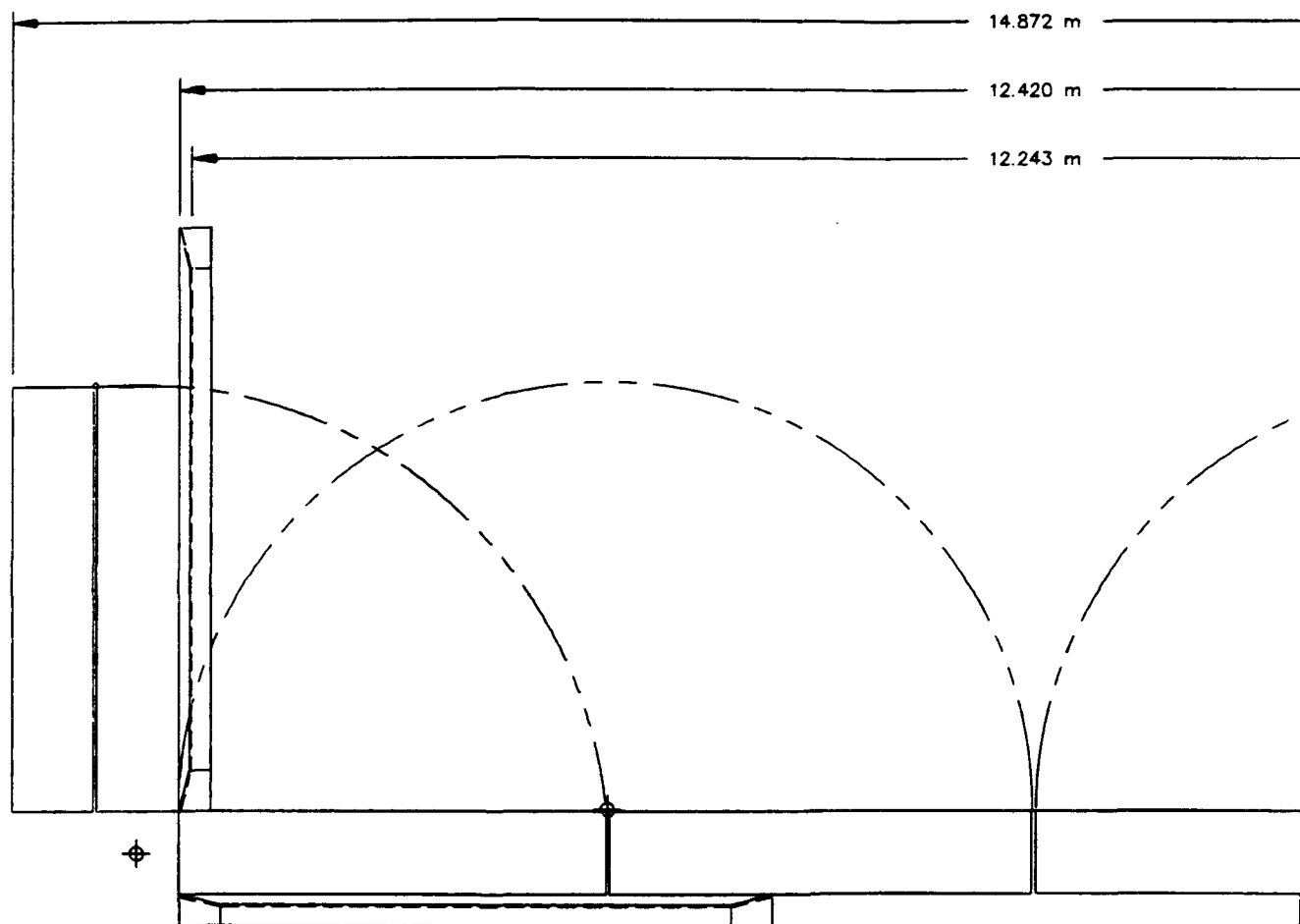
h_1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD
(MINIMUM 4.140m, MAXIMUM 6.210m)

h_2 = VERTICAL DISTANCE BETWEEN DECKS
(MINIMUM $h_2 = h_1$, MAXIMUM 6.210m)

NOTE: IF HATCH IS TO REMAIN OPEN WHEN HATCH
ABOVE IS CLOSED, $h_2 = h_1$.



DRAWN BY: CTG		CHECKED BY: CTG		JH Inc. NAVAL ARCHITECTS-MARINE ENGINEERS CHERRY HILL, NJ PORTSMOUTH, VA CRYSTAL CITY, VA				
				CONTAINER GUIDE/ HATCH COVERS				
SUPV'D BY: CF		SIZE B		FSCM CAGE NO JJH		JJH DRAWING NO. 2852-00-03		REV —
APPROVED BY: CF		SCALE 1/20		N/A		SQ M		SHEET 1 OF 3

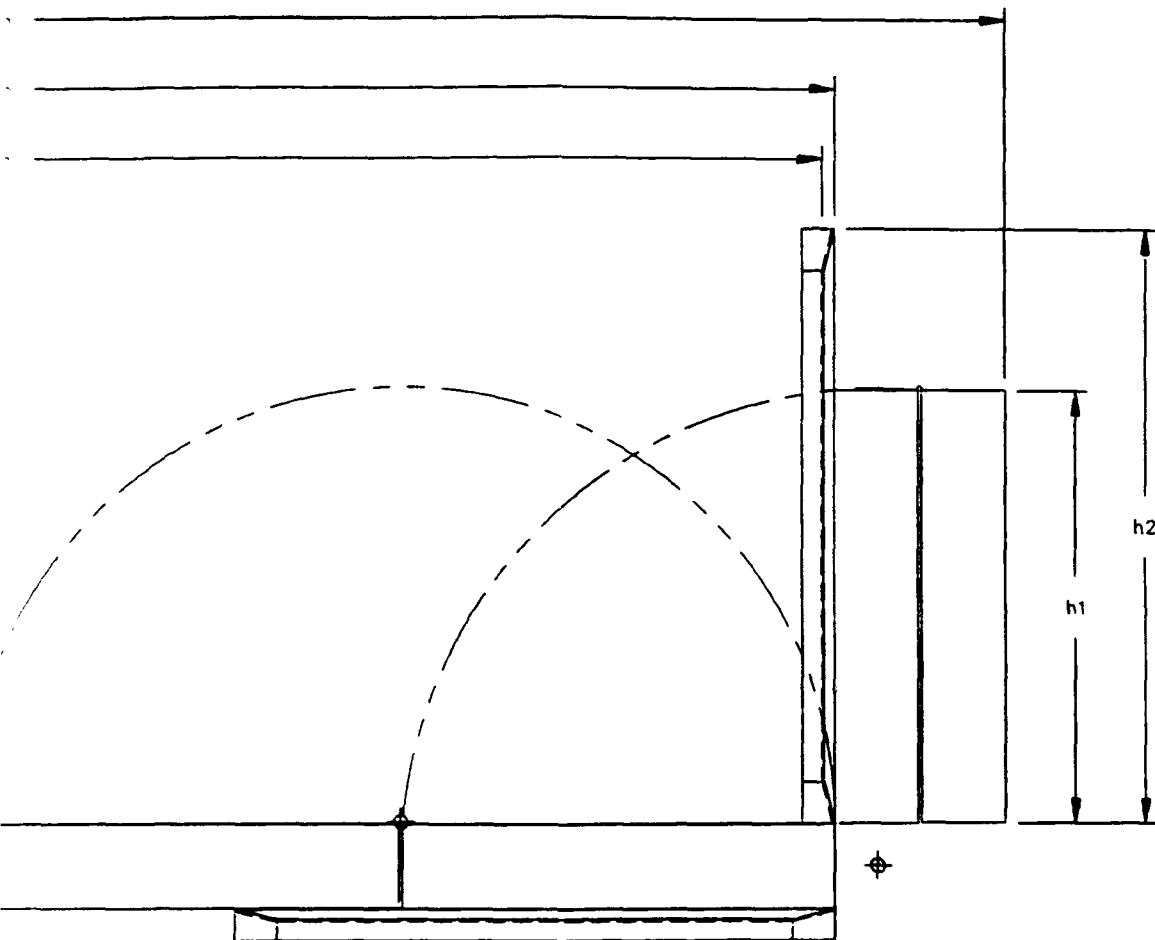


h_1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD
(MINIMUM 3.105m, MAXIMUM 6.210m)

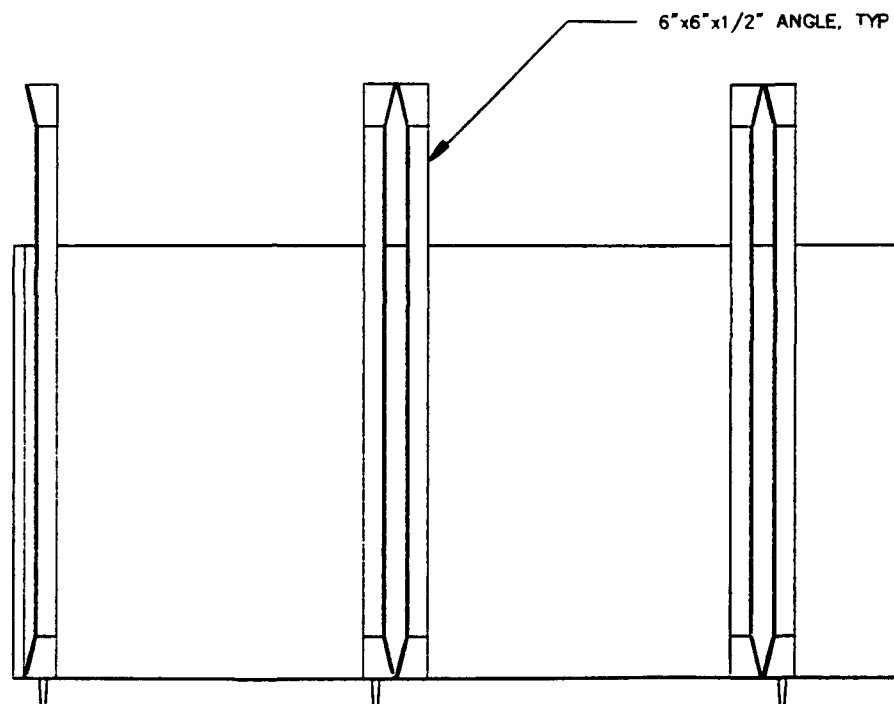
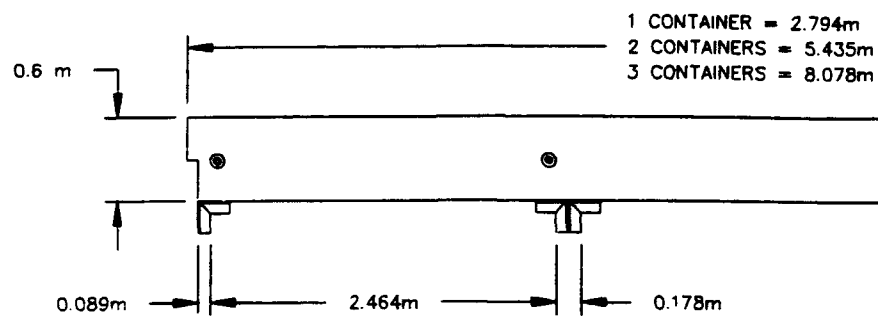
h_2 = VERTICAL DISTANCE BETWEEN DECKS
(MINIMUM $h_2 = h_1$, MAXIMUM 6.210m)

NOTE: IF HATCH IS TO REMAIN OPEN WHEN HATCH
ABOVE IS CLOSED, $h_2 = h_1$.

DRA
C



		SIZE	FSCM CAGE NO	JJH DRAWING NO.	REV
DRAWN BY:	APPROVED BY:	B	JJH	2852-00-03	-
CTG	CF	SCALE	1/20	N/A	SQ M
					SHEET 2 OF 3

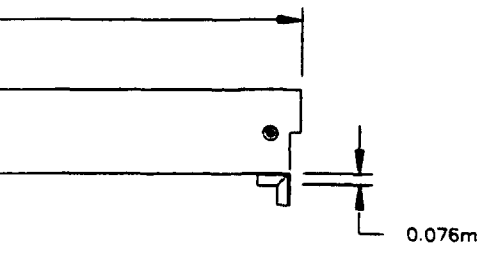


h1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD
(MAXIMUM 6.210m)

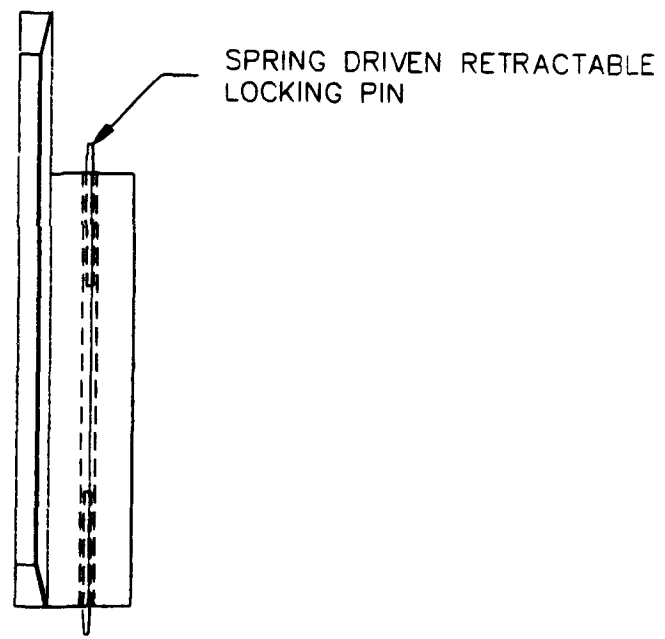
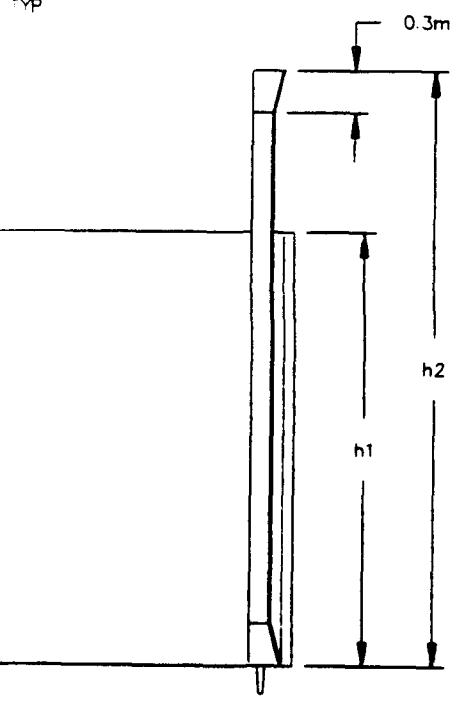
h2 = VERTICAL DISTANCE BETWEEN DECKS
(MINIMUM h2 = h1, MAXIMUM 6.210m)

NOTE: IF HATCH IS TO REMAIN OPEN WHEN HATCH
ABOVE IS CLOSED, h2 = h1.

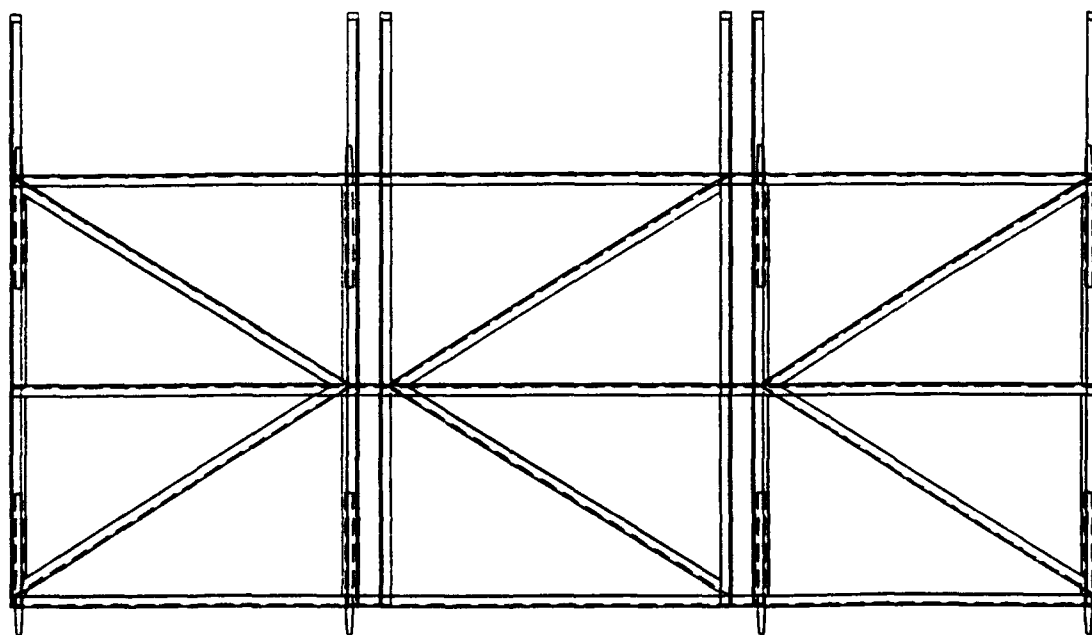
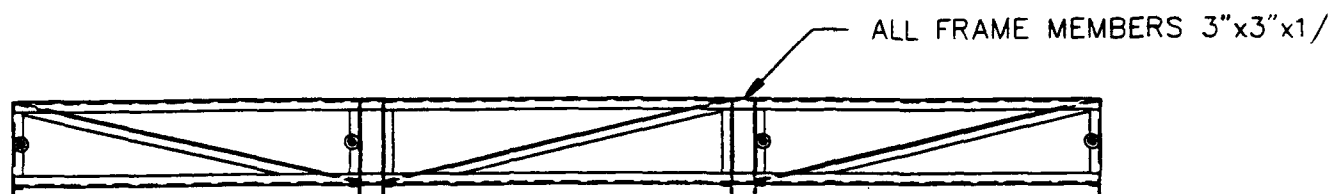
DRAW
C



TYP



		SIZE	FSCM CAGE NO	JJH DRAWING NO.	REV
DRAWN BY:	APPROVED BY:	B	JJH	2852-00-03	-
CTG	CF	SCALE	1/20	N/A SQ M	SHEET 3 OF 3



GUIDE S
3"x3"x1/2"

PORTABLE CONTAINER GUIDE SUPPORT FRAME

NOTE: GUIDE RAILS REMOVED FOR CLARITY

MEMBERS 3"x3"x1/2" ANGLE

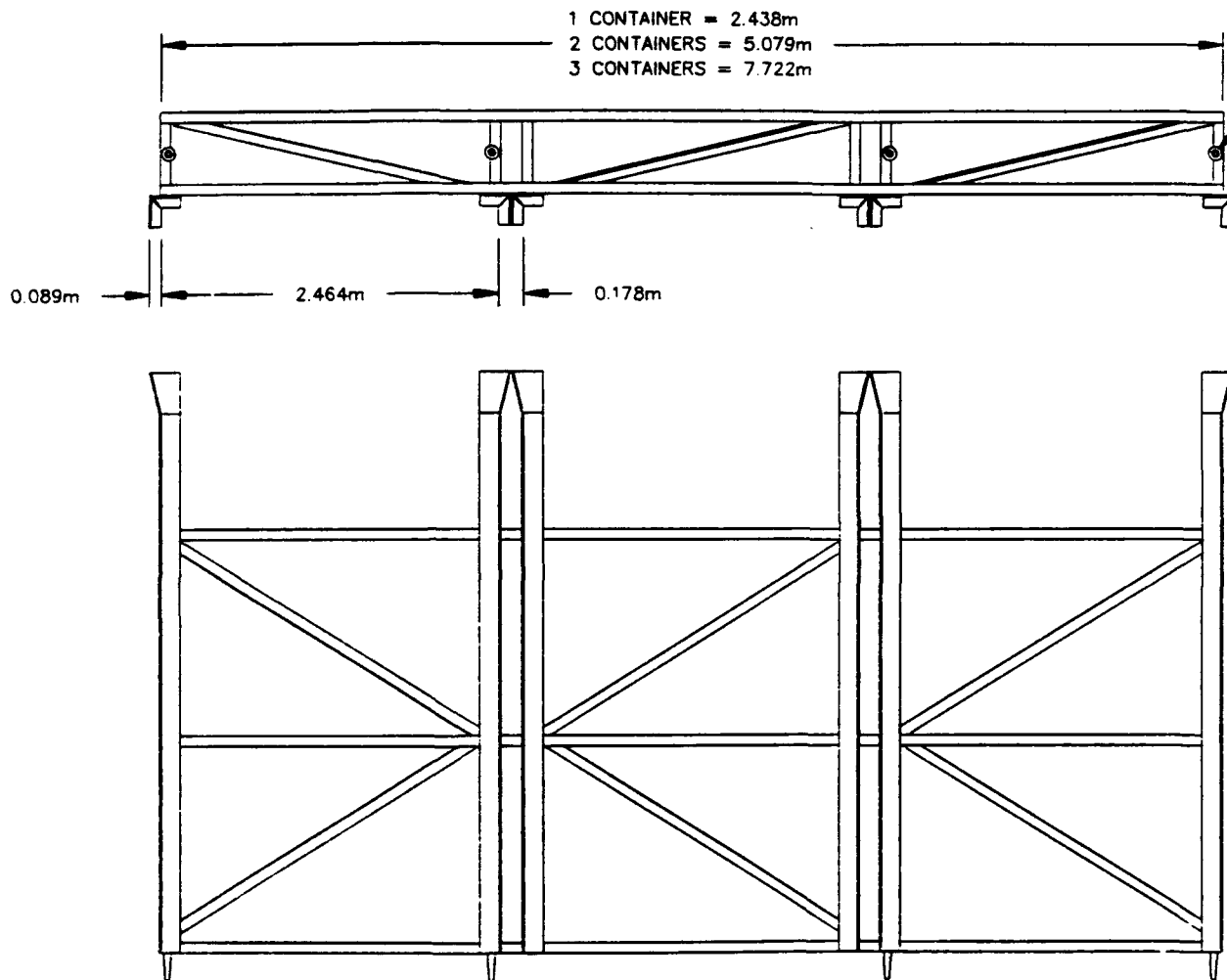
GUIDE STIFFENERS
3"x3"x1/2" ANGLE

SPRING DRIVEN RETRACTABLE LOCKING PINS



AME

		SIZE	FSCM CAGE NO	JJH DRAWING NO.	REV
DRAWN BY:	APPROVED BY:	B	JJH	2852-00-04	—
CTG	CF	SCALE	1/20	N/A SQ M	SHEET 2 OF 2



h1 = VERTICAL DISTANCE FROM DECK TO OVERHEAD

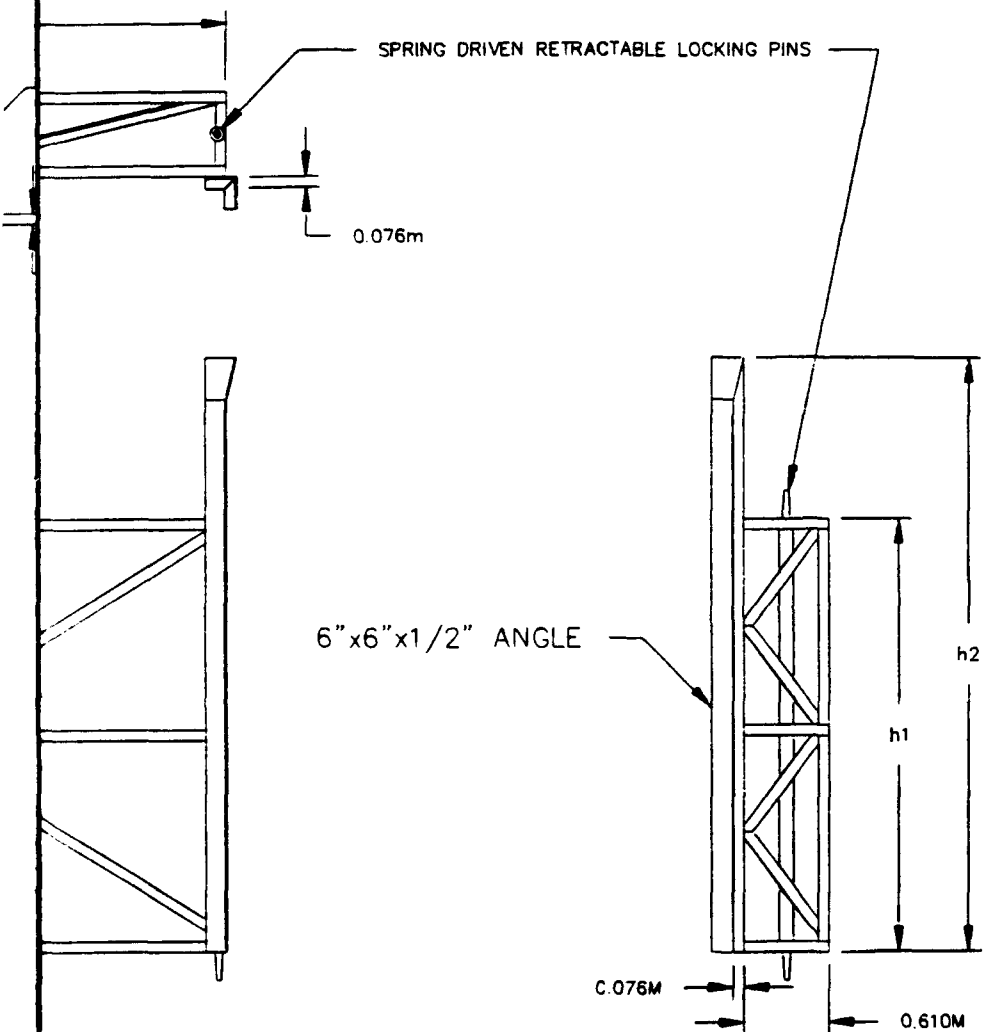
h2 = VERTICAL DISTANCE BETWEEN DECKS


NOTE: IF HATCH ABOVE IS TO BE CLOSED WHILE
 CONTAINER GUIDE IS IN PLACE, $h2 = h1$.

DR

SU

AP



		 JH Inc. NAVAL ARCHITECTS-MARINE ENGINEERS <small>CHERRY HILL, NJ PORTSMOUTH, VA CRYSTAL CITY, VA</small>		
		CONTAINER GUIDES - PORTABLE		
DRAWN BY: CTG	CHECKED BY: CTG			REV
SUPV'D BY: CF		SIZE B	FSCM CAGE NO JJH	JJH DRAWING NO. 2852-00-04
APPROVED BY: CF		SCALE 1/20	N/A	SQ M SHEET 1 OF 2